

BULLETIN UNIVERSITY OF MONTANA.

No. 16.

BIOLOGICAL SERIES No. 5.

Lectures at Flathead Lake

A Series of Lectures delivered at the University of Montana
Biological Station at Flathead Lake, by the Staff of Instructors,
Session of 1902.



UNIVERSITY OF MONTANA, BIOLOGICAL STATION, BIGFORK, MONT.,
UNDER DIRECTION OF MORTON JOHN ELROD.

University of Montana, Missoula, Montana, U. S. A.
1903.

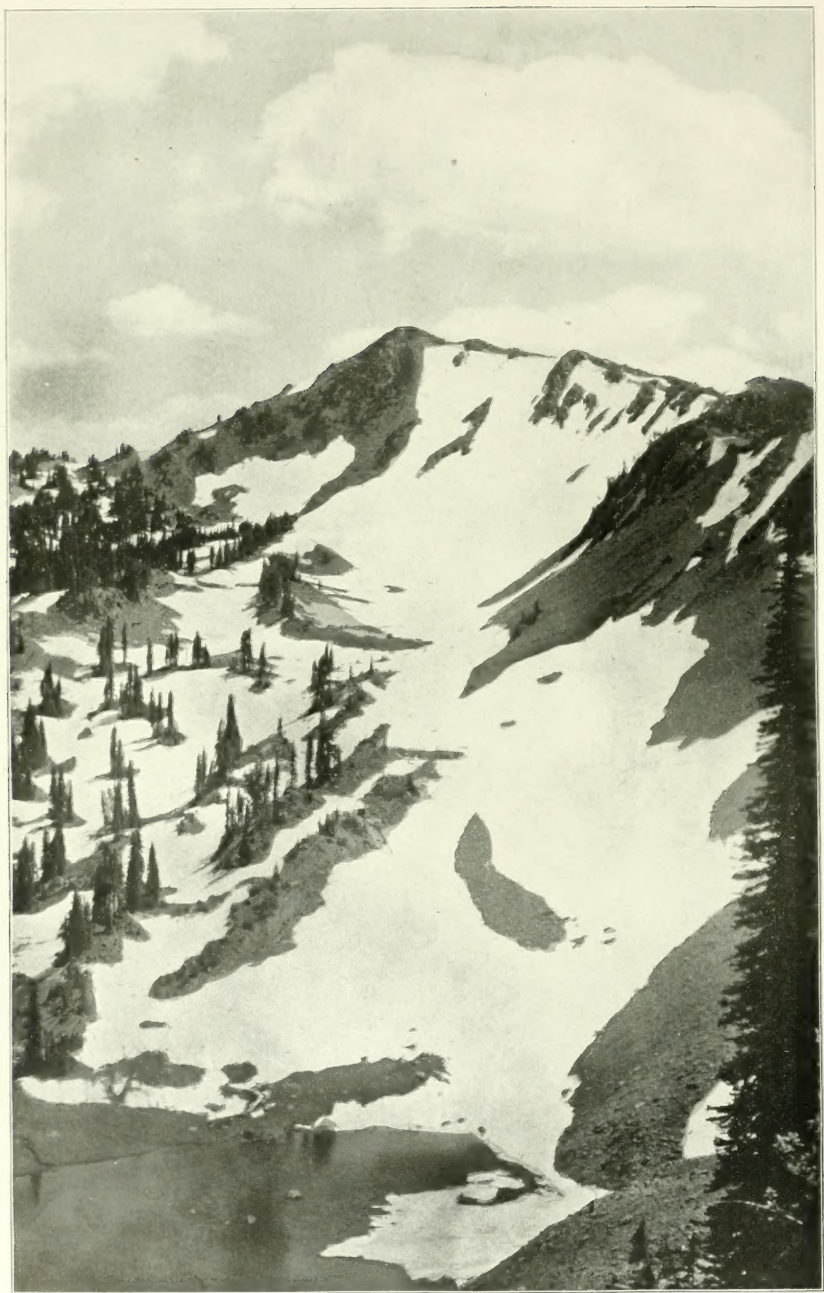
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MacDougal Peak, Swan Range, from the ridge, showing snow field with ice. Note how the timber seeks the drier ridges. Photo by M. J. E., August, 1902. The view is south. Altitude of summit, 7725.

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LECTURERS AT THE UNIVERSITY OF MONTANA BIOLOGICAL
STATION, 1902.

Morton John Elrod, Professor of Biology, University of Montana; President, Montana Academy of Sciences, Arts and Letters; Director of the Station.

Harry Nichols Whitford, Assistant in Botany, University of Chicago, and Collaborator in Bureau of Forestry, United States Department of Agriculture.

Perley Milton Silloway, Principal Fergus County, Montana, Free High School, Author of "Some Common Birds."

Maurice Ricker, Principal Burlington, Iowa, High School, Member Iowa Academy of Science.

INTRODUCTION.

The material presented in this bulletin consists of a number of lectures or talks delivered at the University of Montana Biological Station in the summer of 1902, by the station staff. Not all the lectures are given. Many of the illustrations, such as photographs, charts, and drawings, have of necessity been omitted, owing to the expense of reproduction. The lectures on protective resemblance and mimicry were illustrated by numerous colored drawings and charts, the work of Mrs. Maurice Ricker. But few of these can be reproduced, and they only in black and white. While the absence of numerous illustrations is to be regretted, it is thought the material presented will be of sufficient aid to warrant publication.

The lectures are given for a double purpose.

1. They should be of great service to teachers of the state in nature-study work. Several are prepared expressly for this purpose. Some of those treating of particular features of the locality may by slight modification be made to apply to other localities. There has been an urgent demand for just such information as is here presented, and the publication of the lectures will answer many inquiries that have been received.

2. They will put before the people of the state some of the results of original work carried on at the station. This is all the more desirable since nearly all the observations in a new locality must for a time be new, and hence deeply interesting. It is hoped they will show in part the wide field open for research, and encourage the attendance of many who are seeking such a place for study.

Since the lectures or talks were delivered to audiences of whom many were unacquainted with the subject and with technical terms the simplest language has been used, thereby making them of greatest service.

M. J. E.

Missoula, Mont., April 27, 1903.

The Physiography of the Flathead Lake Region.

Morton John Elrod.

The first thing one must do in a new locality is to become familiar with 'the lay of the land.' The surface geography and geology of a region must first be understood if one is to seriously discuss the botanical or zoological life. The character of the soil determines to a large extent the general character of the vegetation, and the surface irregularities will indicate the nature of the zoological life. In a region where roads, fences, houses, and similar works of man are absent, a knowledge of the country is all the more important in order to get over the country. Since much of the country is as yet unexplored the physiography of the region will be especially interesting to those working at the station.

The views here given are based on the observations of the past four years. Later study may require that they be modified in part, but it is believed the observations will aid very much in working out the exact changes that have taken place in this section of the state. The glaciation of the region offers a good field for detailed work.

The Mission and Swan ranges of mountains, in northwestern Montana, lie parallel with each other, extending north and south in general direction. The Mission range is about seventy-five miles long, ending as a range at the Biological Station. The Swan range extends twenty-five or thirty miles farther north. Both ranges were made by faulting. The stronger throw was at the southern end of the ranges, where the high peaks, reaching 10,000 feet, are found. Between the two ranges the Swan river flows toward the north. It enters Swan lake, still between the ranges, far down the side. From Swan lake the river flows still northward for a few miles, then winds around with a big bend and turns westward through a new channel to its inlet into Flathead lake. That portion of the Swan range which extends north of the Mission range borders directly on the valley north of Flathead lake, rising abruptly from the plain, without foothills.

The formation of the ranges gave to the western side of each an abrupt and steep face, intersected with many ravines and canyons, with more gradual slopes on the eastern sides. The western base of the upper end of the Mission range is washed by Flathead lake which to the greater portion of the distance meets the mountains with abruptness. There is little level or tillable land between, and often scarcely room for a wagon road.

South of Flathead lake a large valley, Mission valley, extends southward for thirty-five miles. North of the lake is another large valley which continues northward to the British boundary. On the western shore a spur range of the Kootenais shuts in the waters of the lake. The outlet of the lake is through a new channel with a series of rapids.

foaming river of wondrous beauty, untouched by man's intervention, with only a trail along the bank and an occasional Indian path to the water's edge for fishing purposes. The lake is about thirty miles long. At its widest portion it is perhaps seventeen to nineteen miles. For the greater portion the width is no more than eight or ten miles.

Two rivers enter Flathead lake. Flathead river flows into the northern end near the center. Swan or Bigfork river flows into the northeast corner, past the site of the laboratory. See Fig. 4. Flathead is much the larger of the two, has a much larger drainage area, and carries into the lake much more sediment. The delta made by the river extends into the lake for more than a mile. Beyond this the lake drops off abruptly to deep water.

The preceding brief statements give the skeleton of the region to be covered in the work of the future, of which the present lecture is the smallest part. Let us consider briefly the agencies that have been at work in remodelling the surface, with the results as revealed by a rather superficial study.

When the mountain ranges were first upheaved their faces were abrupt and perpendicular. The valleys were deep and angular troughs between the ranges, rather than level valleys. It is believed that Flathead lake and the valleys to the north and south were formed by a slip in the faulting process, by which the western portion fell, leaving the mountain ranges as an abrupt border for a comparatively level plain. Evidence for this may be seen in the numerous photographs taken in the two ranges, which show plainly the stratification of the rocks, their slope and dip, and the configuration of the mountain range.

Immediately after this upheaval various agencies began the work of tearing down the ranges, and fashioning them and the valleys into their present forms. The agencies at work have been the wind and air, water, frost and ice, and the vegetation. Vegetation, as also animals, was absent at first, and came gradually, after the disintegration had been sufficient to afford a foothold.

The process of disintegration has continued from the first to the present, and continues now. It will continue until the entire mountain ranges are levelled. The rocks were alternately hot and cold, wet and dry. The small crevices were filled with snow and ice, which made them larger. Larger and larger they became, until pieces, large and small, tumbled from the face of the cliffs. Disintegration was slow or fast according to the nature of the rock. The smaller portions were washed down into the troughs between ranges, filling them up. While the larger channels between ranges were filling up the smaller gorges and ravines at right angles to these and between peaks were being ploughed deeper and smoother by the melting snows from above. The summits were being penetrated by the percolating waters, and the entire mass in some cases rent in pieces by the expanding ice. In some cases the faces of the cliffs fell away until the entire mountain tops fell, leaving the present summits a mass of boulders, still being slowly worn away by the wind and water. This is evidently the case with McDonald peak of the Mission range, as may be seen by the photographs taken at the western summit.

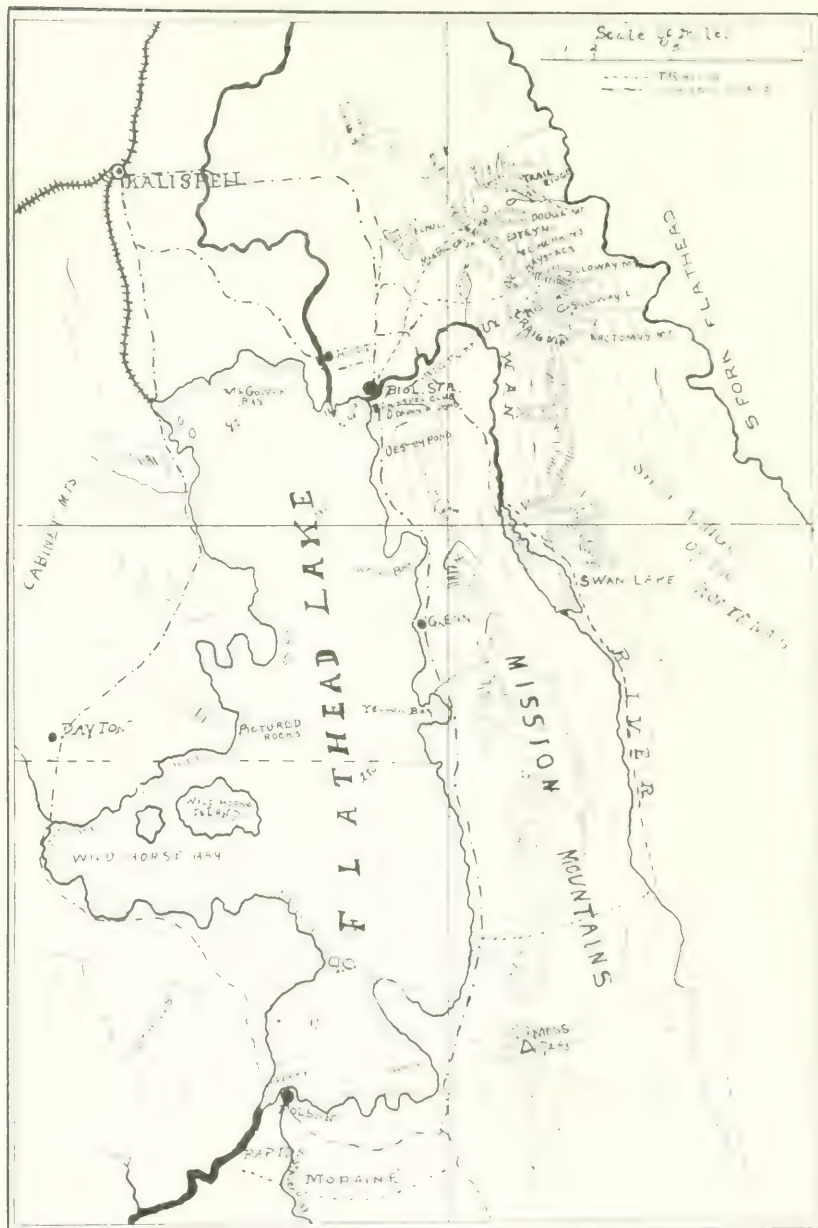


FIG. 4. Map of Flathead Lake and adjacent region.

Lichens were probably the first forms of vegetable life to appear. These probably aided in the process of rock disintegration. As lichens apparently secure the greater part of their nourishment from symbiotic algae growing within their tissue they could and did thrive. Their decaying tissues formed the first vegetable loam which could support the higher forms of life. As other forms of vegetation appeared in succession the soil and rocks were held more firmly in place, making the tearing down process very much slower.

In later times came the ice age. The whole region was covered with a mantle of ice. How deep the river was is mere speculation. From the country adjacent to the laboratory which has been swept by it the depth was many hundreds of feet. At the lower end of Flathead lake a huge dam 450 feet high was left by the ice. At this time the lake was several hundred feet deeper than at present, and covered much of the northern valley, flooding the land on which the laboratory now stands.

How many advances and retreats of the ice mass covered the valley must be determined by more extended study, and by one more competent than I. Whether the main glacial mass was local or continental must be determined by others. From a careful study of the region I can give only the results as evidenced by glacial action.

During the glacial period large masses of ice no doubt slid down the steep mountain slopes into the wider ravines and valleys below, in the same manner as ice masses on mountain tops at the present time. These glaciers flowed into one large glacier whose movement was occasioned for the most part by the pressure from behind. The present valley of the Swan river was filled with ice whose movement was northward. At the same time a much larger ice mass was crossing the wide lake valley from the north. I am not able to say whether the ice mass slid over the frozen lake or whether it aided in gouging out a deeper bed. I am inclined to the former view.

This will be better understood from a study of the map of the region, Fig. 4. The first ice river had a direction represented by the present bed of Swan river. The second and larger ice mass had a direction across Flathead lake from north to south. At the low end of the Mission range these two forces met. The larger turned the smaller first at a right angle, then back on its course, but on the opposite side of the Mission range. On the ground in the immediate vicinity of this laboratory this meeting took place. It must have been a grand sight could it have been witnessed.

Also consult Fig. 5, which is a photograph from the summit of MacDougal peak in the Swan range. The Swan river ice flow came down from the left in the picture. The main flow was from the right. They met in the middle foreground. The lower summits immediately in front of the lake toward the observer were ground over by the ice mass.

On the summits southeast of the Biological Station, which may easily be visited, large boulders, weighing many tons, lie stranded. They are well marked with glacial grooves, and are silent witnesses of the great force which must have been used in their transportation. On some of the summits where the rock strata are undisturbed may be seen deep and

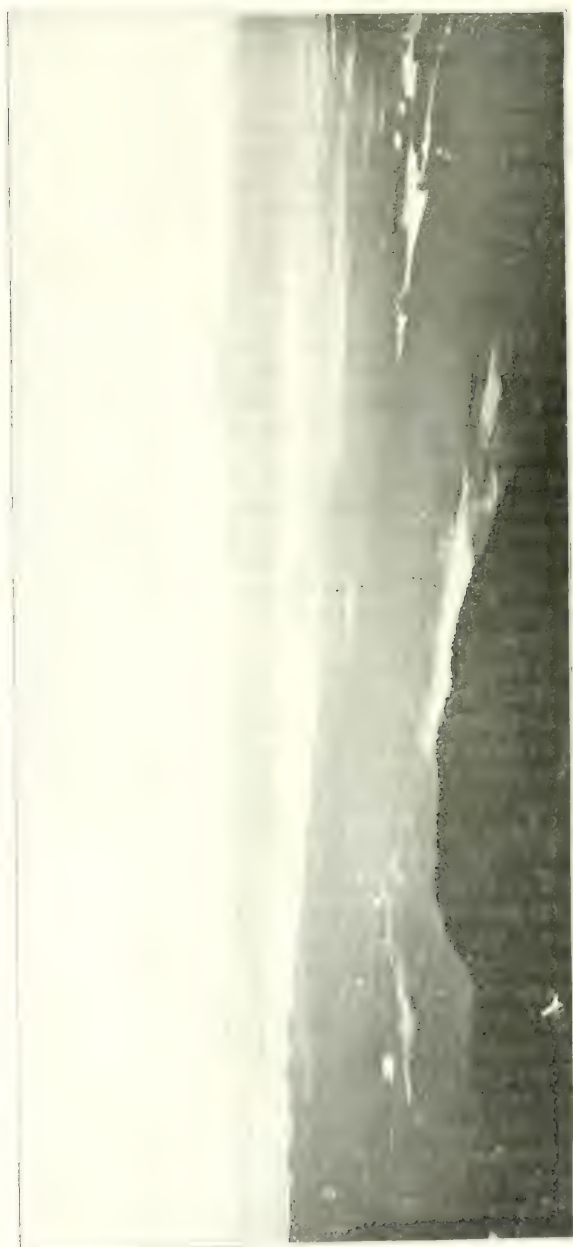


FIG. 1. General view westward from the summit of Mt. Dodagol Peak. In the foreground is the wooded plain of Swan Lake. In the right foreground, Swan River on the left. In the distance is Flathead Lake. The point of land extending into the lake is the delta of Flathead River. Photo by M. J. F.

perfectly plain grooves in the rocks, showing plainly the direction of the ice movement. Also, on the east is the rounded surface made as the ice was forced upward, and on the west is the jagged cliff, unaffected by the ice as it broke off and tumbled over.

The larger ice mass extended across the Mission valley, pushed over the hills south of St. Ignatius Mission, where it left stranded boulders high on the summits, and on past Arlee to the Cabinet range. Whether it passed over or through these mountains I cannot say at this writing. The southern end of the Mission valley is marked by a high moraine. Its exact height has not been determined, but it is several hundred feet. This moraine is much broken, with many inequalities. From this region to the second moraine at the foot of Flathead lake is about thirty-five miles. This territory shows many evidences of glaciation, stranded boulders, hundreds of potholes, banks of pebbly nature, and the like.

As stated previously, the moraine at the foot of Flathead lake is 450 feet above the lake. It extends from the Mission mountains on the east to the Cabinets on the west. Its location may readily be seen by consulting the map again, Figure 4.

At the time this was made the outlet of the lake was through the arm at Wild Horse bay, and through the present Little Bitter Root river. An unusual amount of water caused the lake to rise unusually high, when it overflowed the moraine. The cutting was rapid, resulting in a lower lake level and a new outlet. The terraces at both ends of the lake show the successive levels of the lake at different times. There are at least three, and possibly four.*

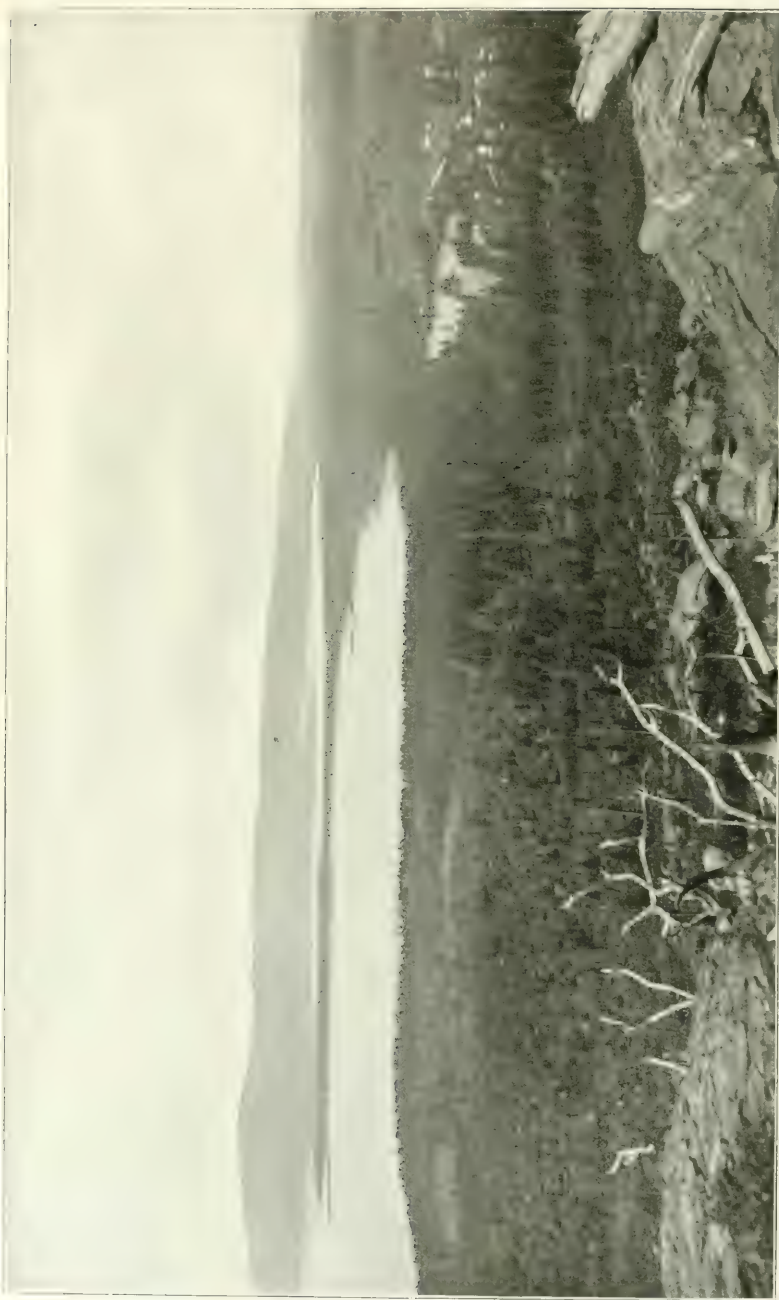
The partial drainage of the lake laid bare a large stretch of country to the north, much of which was flat and swampy. It seems apparent that the Swan river flowed northward along the base of the Swan range, and close to the range, emptying into Flathead river near the present town of Columbia Falls. Evidence for this may be seen in the partially filled swamp lakes, while a distinct old bed may be traced through the timber for the greater distance, a veritable bog swamp for most of the season.

By some unknown means, most likely an unusual ice flow from MacDougal peak, 7,725 feet high, the river must have been dammed, causing a temporary lake. The overflow was across a low pass by short cut to Flathead lake, resulting in a new channel, the present bed, with its beautiful rapids and cascades.

In the earlier time Flathead river must have entered the lake immediately after leaving the mountains. When the lake was partially drained by the overflow of the moraine at the southern end the river meandered over the level mud plain until it found the lake. It cut a very tortuous channel for the greater distance, and has changed many times. In a distance of fifteen miles the river course covers thirty miles.

By the recession of the main ice sheet northward a large amount of morainal material was deposited in the valley, showing most plainly in a line north of the end of the Mission range. This line of morainal material

* This view is confirmed by Eliot Blackwelder, from the University of Chicago, who visited the region in 1902.



Upper end of Flathead lake, and valley, from Prospect hill. The tongue of land is the delta of Flathead river. Swan river is on the right, entrance to lake hidden by the forest. The laboratory is on the right bank of the river, the tents showing. The view is almost west. Photo. by M. J. E.

caused the waters of Swan river to be hemmed in between the Swan range and this glacial matter. When the river made its new channel to the westward the old channel was abandoned and soon filled up, owing to the fact that it had little fall, and was probably surrounded by dense forests such as now cover the region. A number of deeper places still hold water, forming some of the lakes in that region. The nearest of these to Swan river is Rost lake, which is less than two miles from the river. Next is Echo lake, north and west. It is quite certain that Echo lake was not a portion of the old river bed, but was formed by glacial action. Still farther north is Blaine lake, not yet visited, but lying in the old river valley.

Rost lake is nine miles distant from the laboratory northeast. It is about a mile long and less than ten feet deep in the deepest portion. In most places the water is less than three feet deep. It is bordered by dense forests, and is a dead lake, which in a short time will be a peat bog similar to many other swamps in the region.

Echo lake lies north and a little east of the laboratory. It is a land locked lake, with no surface outlet. Notwithstanding this it has several species of fish. Its outlet is underground through glacial drift, coming to the surface through large springs whose waters flow into Flathead river. The surface of Echo lake is quite unstable, and is likely to rise or fall any season. The lake has had very little study.

Swan lake has previously been mentioned. It is reached by wagon roads from the laboratory, the shortest being about eight miles long, the other about fourteen. Swan lake for the greater portion of its length is but an expansion of the river, hemmed in between the Swan and Mission ranges. Its location may be understood by an examination of the map, Fig. 4. This map is incorrect in part, as the upper end of the lake widens into a circular bay some two miles broad, bordered on the south by a large swamp. This swamp is covered densely with vegetation, and gradually gives way to grassy meadows, which in turn are bordered by dense forests.

The delta of Flathead river (Plate XLVIII) is worthy of extensive study, and is a good illustration of the method of filling up by sediment from a river. Very little sediment has been deposited by Swan river as compared with the Flathead. This is to be expected, since the former carries much less water than the latter. But the difference is very marked.

West of Flathead lake nothing has been done, and consequently little can be said concerning its physiography. This hasty and superficial view of the region will give those at the station an idea of the country in general, and will suggest more detailed study in many lines. There is still much to be done. The higher slopes of the Mission and Swan ranges have had very limited study. There are many lakes not yet visited. Much is left for the work of the future.

How to Study a Bird.

NATURE-STUDY LESSON.

Perley Milton Silloway.

The prime object of nature-study is the training of the powers of observation in such a manner that they shall minister to the higher intellectual faculties. It is not an end, but a means, whereby the observer obtains a stronger grasp upon the larger relations of life. Nature-study does not consider the probable destiny of the pupil as a botanist or a zoologist, but as a student of life in any or all of its relations, assuming that all Nature is simply environment which is to react upon the mind and develop its noblest faculties. Life is everywhere about us, and nature-study aims to teach anyone to see, hear, and appreciate that life, whether manifested in animal or plant. Hence the essential method of studying a bird is to cause anyone to see, hear, and appreciate the bird, and to consider its relationships as a part of the vast domain of Nature.

The primary step in the study of a bird is identification. The bird must be recognized, and to make recognition successful the object must be seen under circumstances which admit of definite observation. If the bird is a new one, a rapid inventory of the essential features of its description must be taken, and a fair idea gained of its size, form, color, and markings. The idea of size may be comparative, as somewhat larger than a chipping sparrow and smaller than a robin, or about as large as a pigeon. Attention must be given to the bird's form, or the general outline of the body. It may have elongated neck and short legs, like the geese; it may have both long neck and long legs, like the herons and cranes; it may be rather stoutly built, like most of the sparrows; or it may have a comparatively large head, like the flycatchers.

The prevailing colors must be noted, as general color of the upper parts, lower parts, head, wings, and tail. Then any striking markings should be carefully observed, as these markings are generally the quickest and surest means of identification. For instance, suppose we see a bird of black plumage, somewhat smaller than the robin, rather stoutly built, with prominent white bar on the wing. Upon reference to our book of descriptions, we learn that our new acquaintance is the lark bunting. Suppose we meet a blackbird, somewhat larger than our common friend of the feed-lot, with prominent yellow and white markings; we easily learn that our new friend is the yellow-headed blackbird. All these features in the foregoing descriptions should be promptly jotted down in a note-book, to be used when a key can be consulted.

The actions of the bird at the time of observation are especially important, for they often serve as a key to the family or group to which the bird under observation belongs. There are peculiar characteristics

of certain groups of birds, as the flirting of the tail by the smaller flycatchers, the deliberate folding of the wings by the plovers upon alighting, the teetering of the body by the smaller sandpipers when standing or walking, and similar actions which will occur to your own mind.

The special appearance of any bird is a great help in recognizing or identifying it. It may assume some characteristic attitude that will have a likeness to pictures we have seen or may see, and thus we are aided in determining the name of the bird. Suppose we are collecting on the shore of Daphnia pond. Among the rushes we see (though it will take sharp eyes to see it) a slender, brownish bird of rather large size, with elongated neck and head pointed upward in meditative attitude. We remember that we have read of the bitterns assuming this posture, and we form an idea which readily aids in identification.

In connection with the description and appearance of the bird we are studying, we should learn to note its movements that seem to characterize the species. The kingbird and other flycatchers will be seen to leave their perch, fly outward and upward irregularly, try to capture a passing insect, turn in air, and quickly alight upon the same or another convenient perch. The sparrow hawk will often hover in air, maintain its place by continued fluttering of the wings, and then swoop down upon its prey, or else continue its quartering flight. We notice a bird somewhat larger than the robin, with enlarged head and noticeable crest. It flies over the water with harsh rattling cry, hovers in mid-air to select a victim in the water below, and then dives head foremost. By these actions we have little difficulty in recognizing the familiar kingfisher. A small bird, not so large as the chipping sparrow, alights upon the trunk of a tree near us, and begins to ascend the bole by a zig-zag course, inspecting the crevices of the bark for lurking insect larvae. These movements aid us in identifying the little brown creeper.

Besides what we have mentioned of movements of the bird as one of a species, it is especially interesting to note what may be called the individual actions of the bird. This constitutes a higher phase of bird study than that mentioned in the preceding paragraph, but it is productive of greater results. It separates the bird in question from its group, and regards it as an individual, manifesting traits for which it alone is responsible. No other bird of the same species may go through exactly the same performance, nor exhibit its impulses of love or hate, courage or fear, anger or pleasure, in just the same manner. It is this phase of bird study that marks such naturalists as Ernest Seton Thompson, John Burroughs, Bradford Torrey, Florence Merriam Bailey, and a few others.

Early in the study of a bird the observer must become familiar with its song, call-notes, or cries. Color is generally difficult to distinguish at any distance from which ordinary observation is made, hence the voice of the bird is the means most useful to the observer in recognizing his feathered friends. In the mating and early nesting season, the songs of the birds are especially attractive, and at that time the music should be so associated with identification that thereafter the song will suggest the author. However, the song season is comparatively short, ending

in early July at its longest, with the exceptions of the song sparrow, the meadow lark, winter wren, the vireos, and a few others. Hence the calls and cries of the birds should be learned if one's observations are to be extended throughout the year. Indeed, in late July and during August, few birds are seen, as then they are strangely silent and it is only by their few calls that their presence can be detected. Many birds which haunt the bush allow only an occasional glimpse of them as they flit through their leafy retreats; such birds must be recognized chiefly by their calls. Others, like the rails, skulk among the reeds of the swamp, and the observer must know their voices if he attempts to note their presence.

The manner of flight soon becomes a matter of importance in our study of the bird. The skimming, darting, ceaseless flight of the swallows is vastly different from the whirring wing-movements of the grouse. The low, undulating flight of the sparrows is altogether a different movement from the flitting, capricious, restless evolutions of the terns and gulls. The hawks and eagles flap and soar overhead in ever-widening circles which carry them cloud-ward; the longspurs mount upward in irregular, progressive gradations, and then descend with outspread, unmoving wings, parachute-like, singing as they descend. Our friend robin speeds through the air from point to point in a straight-away course, while the catbird flits from bush to bush with labored action and flipping tail. The flight is so characteristic that it becomes an important aid to bird recognition.

If one is to know much about a bird, he should know where to look for it. To study the bittern one must go to the reedy bog. For the sandpipers we must look along the sandy shore of lake, river, or pond. The song sparrow chooses the bushes bordering the water, while the vesper sparrow resorts to meadows rank with grass. The redstart hides the beauty of its black and orange-red plumage in the depths of the swamp-woods; the meadowlark scatters its ringing melody over the open fields and meadows. Audubon's warbler revels in the depths of the high coniferous woods; the vireos chant in the lower story of the deciduous trees. The American dipper loves the vicinity of splashing falls and foaming rapids of the mountain streams; the handsome lazuli bunting prefers the edges of clearings or the telephone wires of the roadsides. Thus we see that each species has its characteristic haunts, and a knowledge of these haunts is an essential part of our study of the bird.

The migrations of a bird, the time of its arrival in a neighborhood if it is not a resident, and its departure, form a leading part of one's knowledge of the birds of any locality. Many birds can be studied only while they are loitering in a neighborhood a few days in spring or fall as they journey northward or southward in their seasonal movements. The date on which any species is seen, whether an old friend or a new acquaintance, is worthy of permanent record. When to look for a bird is as valuable knowledge as where to look for it, or how it looks. The notes regarding the time of occurrence of any bird in one's neighborhood will form a series of observations which in time may be collated into definite information of the bird's local and seasonal movements.

The study of a bird really becomes an investigation of its relationships of environment. The most important of these relationships, from an economic point of view, is the food of any species, a phase of study which opens an almost limitless field for investigation. What a bird eats is information of practical value to the rancher and horticulturist,—not what a bird eats at some particular season, but what constitutes its bill of fare for the entire period of its sojourn in the locality. Many of the birds are invaluable assistants of the agriculturist. Frank M. Chapman mentions a cuckoo whose stomach at six o'clock in the morning contained the remnants of forty-three tent caterpillars. It was found that four chickadees had eaten 1,028 eggs of the cankerworm, and four others had eaten 600 eggs and 105 female moths of the same noxious insect.

Many ranchers regard the hawks as their enemies, because they are reputed to catch up an occasional young chicken. With the exceptions of Cooper's hawk, the sharp-shinned hawk, and the goshawk, in this region, this belief is quite erroneous. It has been ascertained that 90 per cent of the food of the so-called "chicken hawks" consists of injurious rodents and vermin. A single owl in two hundred meals was known to eat 450 destructive mice and similar vermin. The great horned owl is perhaps the only exception among the nocturnal rapacious birds. Instead of killing the hawks and owls indiscriminately, it would be wiser for the rancher to raise a few additional chickens for the use of his feathered allies. The horticulturist can easily afford to plant a few extra trees to supply the fruit-eating propensities of some of the birds, which live chiefly on insect food during the remainder of the year. When any known bird is seen to capture an insect under circumstances such that the prey can be recognized, or when the bird is observed eating vegetable food, a note should be made of the fact, and as continued observations are made a fair estimate may be computed of the economic value of the species.

The manner of the bird's taking its food furnishes an interesting subject of study. The flycatchers capture their prey a-wing, flying outward from some post of observation, snapping down upon a flying insect, and returning to their perch. The chickadee gleans from the crevices of the bark along the branches, finding insects and larvae that other birds have overlooked. The robin uncovers the worms lurking near the surface of the soil, or finds the destructive larvae burrowing in the roots of the grass-tufts, or else boldly visits the garden and helps himself to the ripening fruit. The osprey wheels above the lake or river, hovers in air when he spies a likely victim below, dives flatwise into the water, and emerges with his finny prey. The swallows flit in rapid evolutions, seemingly on tireless wing, in quest of flying insects, and seldom taking their prey in any other manner. The manner of feeding is quite characteristic, hence it serves as an important aid in identification, besides offering the student a subject for many valuable notes.

The bird's relation to man, in the matter of companionship or association, suggests itself as worthy of consideration. The robin is known to nest in the dooryard; the raven seeks some inaccessible cliff or cave

its brood, and at other seasons it invariably shuns the presence of man. There is a noticeable difference in the dispositions of the representatives of different species, and even of different individuals of the same species in different localities, to confide in the associations of civilization. The bird student will note these differences of disposition whenever they occur to him, and make them a part of his information regarding any bird of his neighborhood.

Furthermore, the disposition of any bird regarding its companions soon becomes very manifest to the observer. He will not see the kingbird many times before its pugnacious spirit exhibits itself in sundry encounters with other residents of its domain or with unwelcome visitors to its neighborhood. No other bird ventures near the home of the humming-bird without quickly arousing the anger of the tiny owner, and the intruder is speedily reminded that he is a trespasser. Quite in contrast to these, the good-natured osprey allows the blackbirds and swallows to nest in the cavities of its bulky habitation. Some interesting scenes of bird-life are brought to the notice of the observer who looks for these incidents of the bird's associations with its neighbors. They are the real key to the inner life of the neighborhood in avian circles, and a part of that higher phase of bird-study of which we have already spoken.

In considering the relationship of the bird with others of its own species, we find that the mating affords a series of profitable and sometimes amusing incidents. More individual character is manifested at this period than at any other, and for obvious reasons the bird disregards much of its ordinary dislike of observation, frequently placing itself in situations where its actions can be easily watched. Most of the traits usually denominated as human are then displayed, jealousy and gallantry characterizing the males, while constancy and modest coyness are noticeable in the conduct of the fairer sex.

The courting and mating among some of the grouse is an instance of the amusing scenes at this season in birdland. The males congregate at a convenient place in the neighborhood, go through a series of struttings, with inflated necks and drooping, quivering wings, apparently displaying all the accomplishments of form and movement at their command, after which the most successful competitor takes the lady of his choice and the couple begin housekeeping at once.

Careful attention to the singing of any bird will disclose the fact that any performer has a variety of musical numbers in his repertoire. Our mountain song sparrow has at least half a dozen separate songs at his command, and I have known the same male to sing as many as eight different arrangements of his notes. The western meadowlark has from six to eight different songs, and with all the variations of the different songsters of this species, it is likely that twenty to thirty varying meadowlark songs could be formulated. The same song will be uttered several times, then a variation will follow for several renditions, and thus change after change may be noted. In the singing there is manifested the same individuality as in other phases of the bird's activities, so that it is possible for the attentive bird-student to identify particular birds in the neighborhood by the execution of their songs.

The nest building of the bird, its home-keeping, and other domestic affairs, constitute the most interesting period of its annual round to young observers. Volumes have been written about the nesting time, as at that season the study of the bird presents its most fascinating side. Children are usually so interested in the nests, eggs, and young that the safety of the nest is imperiled. The teacher should make a collection of old nests in the fall, or lead the children to bring them in, studying the sites and surroundings, and thus sustaining an interest aroused when the birds were using their habitations in the earlier season. The history of the young in the nest has come to be a vital part of the study of the bird. If properly directed, children will be deeply fascinated in observing the events which mark the rearing of a brood of young birds in their nest.

The study of a bird implies that the bird itself should be the subject of study, primarily a-field. The interest of the pupil may be stimulated until many common birds, at first unknown, will be observed, identified by the teacher's aid and by colored plates or descriptions, studied as a part of the neighborhood's wealth of wild-life, and thus a zeal for bird study aroused that will cause the observer to become a life-long friend of the birds. A bird may be observed by one of the pupils, or may be familiar to only one, but the knowledge of this one may serve as the teacher's means to introduce the bird to the entire school. Little by little the acquaintance is extended, until all become friends of the bird. Meanwhile others are brought to notice, and in a comparatively short time the majority of the pupils have established friendly relations with all the common birds of the locality. If any accessible literature concerning bird-life has been brought before the children, not only has Nature's door been opened to them, but they have made a step into the realm of literature, from which none of them will voluntarily turn back.

Introduction to Studies on the Fertilization of Plants.

Maurice Ricker.

The subject of fertilization in plants is introduced by a consideration of the life history of an oak. This tree is usually well known, as a tree. Some have shown surprise that it has a flower and thus I am able to obtain the interest and attention, so necessary in the treatment of a nature study subject. To go to the complex forms of adaptation at one bound would fail to give those who are wholly without botanical training the necessary insight into the anatomy and physiology of flowering plants. This treatise is an attempt to put this necessary information into words of one syllable, as it were.

Let us begin the study of an oak with the beginning of the plant, not as a separate individual, but with the formation of the mother cell which is afterwards to give rise to the plant. Brown and Mohl about 1840 showed that all organs were traceable to the one cell from which all the others are formed. During the past fifteen years some of the foremost biologists have devoted much time to the study of the cell. They have written many volumes and worked out many interesting things, even to some interesting studies of the difficult problem of inheritance. But we shall have little time for the consideration of their conclusions. It will suffice for our present purposes to restate the proposition of the ancients, "Like produces like." A black oak tree originated from an acorn borne upon a black oak tree. Of course the exception, so firmly believed in by all small boys, of the snake being produced from the horse hair, has to be dealt with. True the boy has not proved this by his own experiment. The one he tried was planted in the wrong time of the moon or in the wrong kind of a bottle, but he always knows some one who did grow a true snake from a horse hair.

Aristotle taught that life originated from ocean slime. He was unable to find proof of any material change in species. The last great pre-Darwinian battle was fought in the debate in Paris between St. Hilaire and Cuvier less than a week before the revolution of 1830. Cuvier won, at this time, by stating authoritatively that skeletons show no change in form, even of the cats buried 3,000 years before, with mummies in Egypt. He overlooked the fact that conditions of environment which might lead to change in structure had remained constant likewise during the same length of time. We may defer the discussion of change and state that black oaks come from black oaks, white oaks from white oaks, burr oaks from burr oaks—let us see how.

We readily find the small yearling oaks under the parent tree. On pulling them up we find the well known acorn. We know this acorn grew upon the tree above. If it is spring-time we find no ripened acorns

on the living limbs, but the dead branches broken by late summer winds give the proof, if any is needed.

Closer observation of the black oak reveals the little miniature acorns on the previous year's growth, in the axils of the leaves. It would require little reflection to see that these are the acorns to ripen in the fall.

In similar positions on the fresh young shoots of this spring's growth, in the axils of young leaves, may be found corresponding structures one year younger. The fleshy growth with the three reflected lips is the female flower. But 'what a flower!' I exclaimed, when I first saw it. It is devoid of the showy envelope which we associate with this word. A perfect flower is one that has both pistils and stamens; that of the oak has a pistil only, or anthers only. It is therefore an imperfect flower. A flower with both pistils and stamens and both whorls of the floral envelope—the outer one, the calyx and the inner, the corolla—is called a complete flower. Such is the apple blossom.

The sticky surfaces of the three lips are the stigmatic surfaces and the part bearing them—the stigma. The swollen attached end is the ovary. The stem connecting the stigma with the ovary, in this case quite short, is the style.

Sections of the ovary show that the exterior part is a covering for the seed like ovule. By proper methods we could go further and demonstrate the germ cell itself which is in reality the center of life and the cell from which the future oak is to spring.

Near the attached end of the ovule is a small opening into the ovule called the micropyle. By the provisions of nature no plant germ cell can divide and grow into an embryo without the introduction through this micropyle of the growing pollen tube. This pollen tube can grow only when a ripened grain of pollen produced on the anther of the same or another flower, falls upon the stigmatic surface of the pistil when it is in a receptive state. The conditions under which fertilization takes place, for this is the name given to the process just described, form an interesting chapter in plant morphology and plant physiology.

It is my purpose to call your attention to some of the wonderful adaptations in plants and animals which are evidently solely for the purpose of transferring the ripened pollen to the receptive stigmatic surface.

Let us take up the case of the oak. As was stated, the fruit bearing oak is imperfect, and consists of a pistil only. We must look for another flower, therefore, which shall contain the stamens. We call the pistil just examined the pistillate flower. Let us look for the stamens or the staminate flower. In some cases we must look on another plant. When pistillate and staminate flowers are found on separate plants we have a dioecious plant. In the black oak we find the staminate flowers on the preceding year's growth in the axils of leaves. Such flowers are called monoecious.

If you examine the long catkins or aments it will be found that the stamens are borne upon a long stalk. When viewed through a lens a beautiful structure is disclosed. Each stem bears numerous flowers and each flower contains four stamens.

The drawing (Fig. 6) shows the anther on the pollen bearing part.



FIG. 6. The stages of the black oak. On the right, an acorn with young shoot; on the left, young acorns in the axil of a leaf above, fullgrown acorn below; branch with aments; on the right of the branch the unripened stamens above, mature stamens with pollen below. From water color drawings by Mrs. Edith Ricker.

before it has ripened and after it has dehisced or opened, setting the pollen free. The meally yellow dust that is shed so freely at the slightest touch is the pollen. Shaking the branch sets free a perfect cloud of it. It is borne off in the air like a whiff of smoke. Only one pollen grain is necessary to fertilize one ovule. Many pollen grains will of necessity, whatever be the mode of fertilization, fail to reach their intended place upon a ripe stigma. The ratio of pollen grains to the ovules must always be large. The night blooming *Cereus* has 250,000 pollen grains to 30,000 ovules, or about 8:1. The garden wistaria has a ratio of about 7,000 to 1 ovule. The Indian corn, pines and other wind fertilized flowers must have a much greater ratio than this.

One can see at a glance (Fig. 6) that the pollen grains of the oak, because of their position, stand little chance of falling upon the stigma of the branch upon which they are borne. It would require an upward draft of air or an insect or other animal to carry them. It would be easier to account for the transfer of the grain of pollen in this case by supposing it to have dropped gently from the boughs above. It may as well have been carried by a light breeze from a neighboring tree.

There is neither odor, nectar, edible pollen, nor showy corolla, to guide or attract a busy insect, and since all insects seem bent on business they would spend little time loafing around the oak blossom. In fact it would be a one-sided bargain for an insect to carry pollen for the oaks since he would derive no benefit to himself. Wherever a relationship is discovered between a plant and an animal it may be taken as axiomatic that the association is mutually beneficial. Darwin once staked his theory of organic evolution upon the proposition that if any organ or modification of an organ could be found in the animal or plant world that was present wholly for the benefit of another species, that he then must admit that his whole conception might be based upon false conclusions. Fifty years have passed and no one has produced the evidence.

Assuming that a pollen grain has found its place upon a sticky stigma of a pistillate flower let us see what takes place. The grain of pollen absorbs moisture and swells until it begins to grow a tube, somewhat as a seed sends down its radical. It either enters a space left between the cells or by penetrating the cells grows until it reaches the generative cell of the ovary. An interesting series of experiments has been made showing the cause of growth down the style to the ovule to be chemotaxis, or growth toward chemically attractive substance. The essential part of the pollen liquid now penetrates the ovule to the nucleus of the generative cell. There immediately follows an interesting series of phenomena of especial interest to the embryologist. In brief, the one cell subdivides many times and grows ultimately into an acorn, which one year later will be recognized as such a one as now appears on last year's growth. The season's growth increases it to the normal size and in September or October it is ripe and ready to leave the tree, and soon finds its resting place upon the ground. (The white oak and some others mature their acorns in one season. Not all the pistils are fertilized. Some of the acorns fail to grow the second year.) The fallen acorns roll about or are kicked or carried about by animals. Squirrels bury them at some

distance from the tree. A great number are eaten by animals. Many others have been stung by diptera and a little white grub has eaten the food stored up for the plant.

But here and there one in a great many has been pressed into the ground and has felt the warmth of spring. It has split its weather worn casing and protrudes its white radical. The subtle attraction of gravity causes it to turn downward and bury itself still deeper in the earth. From the split in the hypocotyl where it branches to the two cotyledons arises the caulicle or stem. This is the part we will call the tree. The figure (Fig. 6) shows an oak the second year of its growth as an independent plant, or the fourth year from its beginning as a cell.

We will not here treat further of the growth of the tree. To consider in its entirety the manner of growth to the tree again producing acorns would be a treatise on botany too long to be given here.

We have traced the growth through the stages through which, in a general way, all plants of the higher orders must go.

The Forest Trees.

Harry Nichols Whitford.

(The material contained in this and the other botanical lectures is the outcome of a series of talks given at the biological station of the University of Montana at Bigfork, Montana, during the summer of 1902. The description of the conifers is intended to be an aid to the identification of the trees for the use of those not acquainted with botanical terms. In nearly all cases the points of difference between the trees have been tried and found applicable in determining the species. In the preparation of the key and descriptions, the author has made free use of the manuals covering the region and of Sargent's "Sylva of North America.")

An attempt has been made to show why there are **prairie** and **forest formations**. In the **forest formation** itself there are places where there are no trees, and in certain situations some trees will grow where others will not. It will not be out of place to ask why these things are so. But before proceeding, it is desirable to become acquainted with the kinds of trees that are found in the state. This enquiry will be confined to that group of trees called conifers, for the others form an inconspicuous part of the forest. Not only must the trees be known, but also their habits, so that what they will do in certain situations can be predicted.

It is not always an easy thing to distinguish the different species of trees. The difficulty of recognizing young trees from one another is even greater than with older trees; for the older trees may have cones, and these are, of course, more apt to give a clue to the identification. However, even from older trees cones are often absent. The bark of trees is very characteristic, and lumbermen use this mark to distinguish trees. But hereby mistakes are often made, for the bark is different at various ages; and a tree growing in one situation is likely to have different bark from the same species growing in another situation.

The leaves perhaps are less variable in their form than the bark, and as they are more often present than the cones, they will serve as a criterion in discriminating the species. With the exception of the western larch, the leaves of the conifers to be described are on the trees the year around, so the character drawn from them can be used in the winter as well as the summer. Since the leaves even on the same tree vary in shape, often more than one character will have to be used.

A Key to the Conifers of Montana.

- A. Trees with leaves in clusters, excepting those first appearing on young shoots.
 - I. Leaves in clusters of more than five (Bark smooth).
 - II. Leaves in clusters of two to five (Bark pitted).
- B. Trees with leaves not in clusters.

- I. Leaves scale like.
 - a. Leaves four ranked, the side ones ridged, the branchlets thus appear flattened3. *Thuja* (arbor-vitae).
 - b. Leaves four ranked and all ridged, the branchlets thus appear four sided4. *Juniperus* (juniper).
- II. Leaves needle like.
 - a. Leaves jointed from a base that remains after the leaf is shed.
 - Leaves flat, petiolate5. *Tsuga* (hemlock).
 - Leaves sessile, and ridged on both sides.....
 -6. *Picea* (spruce).
 - b. Leaves not jointed from a base that remains after the leaf is shed.
 - Leaves short petiolate leaving a triangular scar when shed7. *Pseudotsuga*.
 - Leaves sessile leaving a round scar when shed.....
 -8. *Abies* (Fir).

The genus *Larix* is easily distinguished from the other genera by the fact that it is the only deciduous conifer in Montana. There are two species in Montana.

Western Larch (1) (*Larix occidentalis* Nutt.):

This tree is known in the Flathead valley as the tamarack or larch. The new shoots have the leaves scattered. In the axils of these leaves appear buds which develop into short branches with a cluster of leaves at the end. Each year this short branch grows slightly in length, and a new ring of wood is added. The growth in length is so little, however, that the branchlets never become long. The leaves are soft compared with the other conifers, and have a lighter green color by which they may be distinguished in the forest. In the fall they turn yellow green and drop about the middle of October. The leaves are about one and a half inches long. Compared with those of other conifers the cones are small, but are about twice as large as the eastern tamarack (*Larix laricina* (Du Roi), Koch.) They are from one to one and a half inches in length. The bract is longer than the scale. (2)

The bark (Fig. 7) of the older trees is smooth at first, then becomes deeply ridged, and when the tree is 75 to 100 years old, it is at the base four to five inches thick. It breaks up into oblong plates and is covered with scales which break off in scroll shaped patterns. These scales are

(1) In this article the common and scientific names suggested by Sudworth of the United States Bureau of Forestry will be used. Nearly all of the western conifers have closely related species in the eastern part of the United States, and many have the same common names as their eastern relatives. It is desirable, therefore, to distinguish them by choosing a name that is not already in use. However, with these there will be given other common names that are in local use. See Sudworth, G. B., Check list of the forest trees of the United States, their names and ranges. Bull. No. 17, U. S. Dept. of Ag., Div. of Forestry.

(2) It may be well to state that the fruit of the conifers, known as the cone, is made up of closely imbricated scales. To the upper surface of each scale, two seeds are attached; on the lower surface, "bracts" are found. Usually the bracts are shorter than the scales.

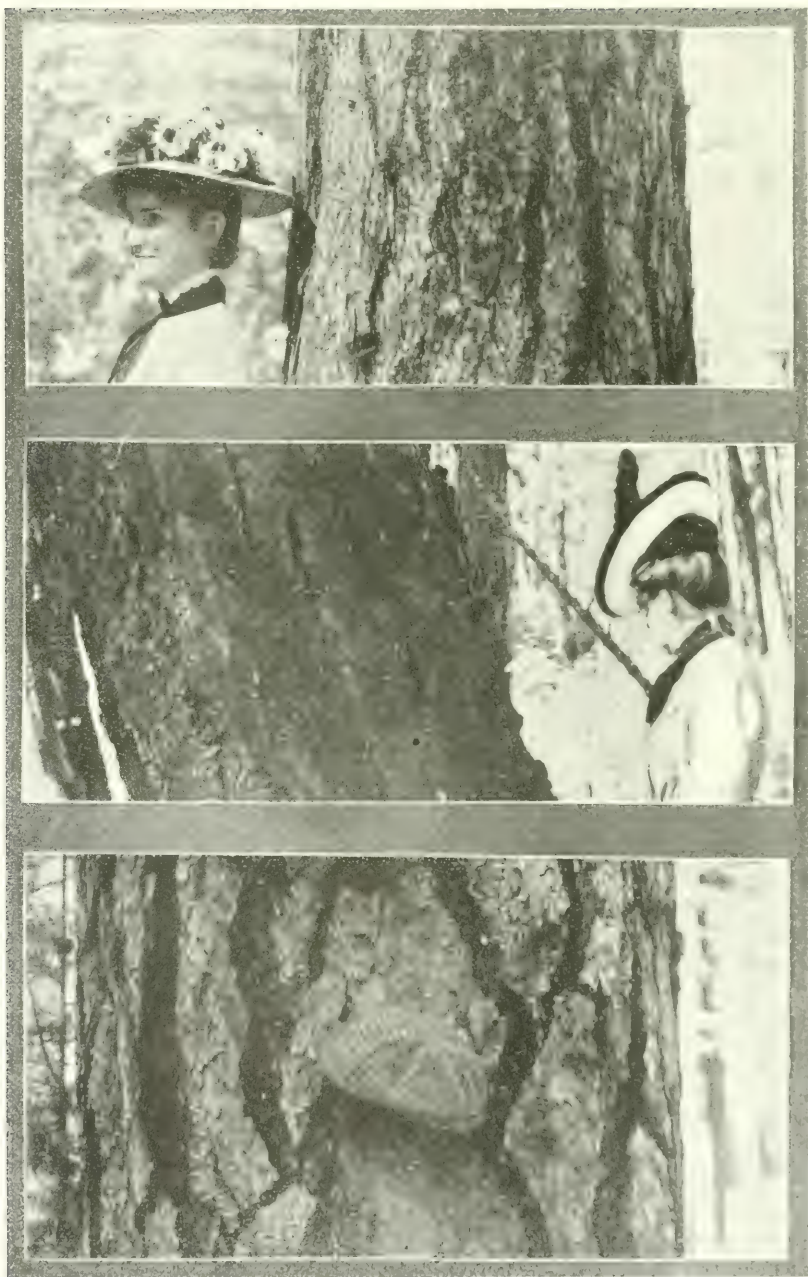


FIG. 7. Comparison of bark. Upper, Larch oak, *Castanopsis dentata* Nutt.; middle, Douglas spruce, *Pseudotsuga taxifolia* (Lam.) Brit.; lower, Yellow pine, *Pinus ponderosa* Laws.

cinnamon red in color. The thick bark enables the tree to resist fires. This is, of course, of great advantage to the tree, for since fires have become more numerous, those trees that are easily destroyed by them are first excluded from the forest. The western larch is one of the last to suffer permanent injury from fires. Those seed-bearing trees that remain after fires will re-stock the burn with a new generation of trees. The western larch requires light in its seedling stages; hence it can reproduce itself only in open places. These may be caused by fire, by death of old trees, or by any accident that will remove the trees of the mature forest. The western larch is then exceedingly intolerant of shade.

In the Flathead valley the western larch does best in soil not too moist nor too dry. This tree is said to reach its greatest development in the basin of the upper Columbia river. In the United States it is most at home in the Flathead valley, and in northern Idaho. Here it may reach the height of 200 feet, with a trunk of five to six feet in diameter, and occasionally is even larger.

Mountain larch (*Larix Lyallii* Par.). The mountain larch is reported to be present in a few places at high altitudes in the mountains of north-western Montana. It does not, however, form a conspicuous element in the forest. It is distinguished from the western larch by the fact that the leaves are nearly as thick as broad. In the latter species the leaves are somewhat wider than thick. The branchlets of the mountain larch are hairy, as compared with those of its lowland relative. The height of the tree is seldom over fifty feet.

The genus ***Pinus* (pine)** is easily distinguished from the other conifers by the fact that the needle like leaves are in groups of two, three, or five. The first leaves that are produced on the leading shoots are scale-like. In the axil of each scale-like leaf a bud may appear which develops soon into a branch, so short and inconspicuous as to be hardly recognizable. On each of these short branches, two, three, or five leaves appear, the number being usually definite in each species.

There are five species of pine in Montana. They may be divided into two groups, viz., those that have two or three leaves in a cluster or fascicle and those that have five leaves in a cluster. The latter, known as white pines, are represented by three species in Montana, and are seldom found growing together. In the Flathead valley the **silver pine** is found only in the lower altitudes. Near the timber line is the **white-bark pine**. (Plate XLVII.) This is usually on the west side of the continental divide. On the east side of the divide at high altitudes, the **limber pine** occurs. Aside from their mode of distribution, these three pines may usually be distinguished from one another by the length of their cones. The cones (Fig. 8) of the silver pine are from five to eleven inches in length, usually not less than eight; those of the limber pine from three to ten inches, most frequently under eight; and those of the white-bark pine from one and a half to three inches. The tips of the cones of the last named species are curved inward. The length of the leaves is variable, but usually in the silver pine they are long, in the white-bark pine and the timber pine they are short; the first of the last two named having the shorter leaves.



FIG. 8. Cone of Silver or White pine.

Silver pine (*Pinus monticola*, Dougl.): This pine is more frequently known as the white pine, or western white pine. It resembles very much the white pine of the eastern part of the United States. The cones of the former are much longer than those of the latter, and the leaves are more thick and rigid, and usually not so long. No tree in Montana has longer cones (Fig. 8) than the silver pine. The leaves of the silver pine are said to remain on the tree from three to four years. The trunk of the young trees has a smooth, thin, light gray bark. In the older trunks it becomes as much as an inch to an inch and a half thick, and is divided into nearly square plates which are very characteristic. When fired, the bark, is easily heated through, the cambium zone (3) is killed, and the tree thus destroyed. In contrast with the western larch the tree is slightly tolerant of shade, that is, it can exist as a seedling in the shade of other trees. In the Flathead valley it is confined to soils that are quite moist. It cannot be said to be a very successful tree here, although in favorable situations it reaches good size. Isolated trees may be

(3) The cambium zone is the active growing region between wood and bark that enables the tree to increase in diameter; in the bark and therefore outside the cambium zone is the region that conducts certain food materials from the leaves to the roots. If these regions be killed, the tree will shortly perish.

found at rather high altitudes, although it was not seen to overlap in its distribution the white-bark pine of the higher altitudes. It is said to reach its best development in the bottom-lands of streams tributary to Lake Pend d'Oreille.

The white-bark pine (*Pinus albicaulis* Engelm.): It is distinctly an alpine form. (Fig. 9.) The leaves are in clusters of five, and from one



FIG. 9. White-bark pine on the slope of Sinyaleamin Mountain, at altitude of 7800 feet, showing the struggle they make for an existence. Photo by Prof. L. A. Youtz.

and a half to two and a half inches in length. They are said to persist for from five to eight years, most of them remaining on the trees from seven to eight years. The bark is very thin. It is quite smooth and is creamy white in appearance, hence the name **white-bark pine**. It is easily destroyed by fire. The white-bark pine grows on the most exposed ridges in high altitudes. It is confined to the western continental divide, where it is usually associated with the alpine fir.

The **limber pine** (*Pinus flexilis* James): The tree may usually be distinguished from the former species by its rougher bark and longer cones. It is found on the eastern side of the continental divide, usually at altitudes of from 5,000 to 10,000 feet.

The two remaining pines found in Montana are the **bull pine** and the **lodgepole pine**. They can be easily distinguished by the length of the



FIG. 10. Leaves and cones of the bull or yellow pine. Photo by M. J. E. leaves and the number in a cluster. The former has usually three, sometimes two, long leaves; the latter, two shorter leaves.

The **bull pine** (*Pinus ponderosa* Laws.): The bull pine, (Fig. 10) more often called yellow pine, is one of the most striking, widely distributed, and most valuable trees of Montana. The comparatively long leaves are usually in clusters of three, though occasionally two are found. They persist usually for three years. They form great clusters at the ends of the naked branches. The cones (Fig. 10) of the bull pine are three to six inches long, and often in clusters of three to five. The tips of the bracts are elongated into a conical characteristic shape. The bark is

very striking. (Fig. 7.) In the older trees it is split up into long rhomboidal plates, covered with scroll-like yellow scales, very much resembling those of the western larch. At this stage the tree is known by certain lumbermen as the **yellow pine**. In the younger trees the bark is more ridged and rounded, and does not have the yellow color. This form goes under the name of **bull pine**. In the older trees the bark is two to four inches thick and very resistant to fires.

In the Flathead valley the tree is confined to the low altitudes, and is more abundant on the border of the prairie, though it does better in moister situations. It is, perhaps, shaded out of these places because of its extreme intolerance of shade. It needs very open places in which to germinate, and very little shade will prevent this. The bull pine and its closely related form, the **rock pine** (*Pinus ponderosa scopulorum* Engelm.), are found throughout the western part of America. The latter has not been reported from Montana.

The **lodgepole pine** (*Pinus Murrayana* "Oreg. Com."): The leaves of the lodgepole pine are in pairs one to two inches long, and remain on the trees seven to eight years. The cones are smaller than those of any other pine in Montana. The tree resembles the **jack pine** (*Pinus divaricata* (Ait.) Du Mont de Cours.) of the eastern part of the United States in its general appearance and some of its habits. The bark of smaller trees is smooth. On the older trees it breaks up into rectangular plates, and is about one inch in thickness. It is a tree easily destroyed by fire, but because it can produce cones at a very early age, it has a very great advantage over the other trees in gaining a foothold in burned areas. Groves of small trees six to ten years old may produce cones abundantly. Another remarkable feature of the lodgepole pine, is that the scales of the cones remain closed, sometimes for several years, thus preserving the vitality of the seeds for a comparatively long period. The seeds from cones nine years old have germinated. The heat of the fires sweeping through a forest will open cones, liberating, though not often destroying the seeds, which germinate at once, and thus give a decided lodgepole pine aspect to the new growth. In closed forests the lodgepole pine has small diameter and great length. Trees over a hundred feet tall often are no more than six inches in diameter. Where there is plenty of room for the lodgepole pine to grow the diameter is greater, and the height less. The lodgepole pine has a rather wide distribution in western Montana. It is usually confined to rather moist situations. So successful has it been in gaining a foothold after fires, that it has replaced many square miles of valuable timber. It cannot tolerate shade, however, and if fires are kept out, in several generations the forest conditions will probably be the same as before the original forest was destroyed.

The **giant arbor-vitae** and the **Rocky mountain juniper** are easily distinguished from the remaining conifers by their scalelike leaves. In the giant arborvitae they closely overlap. In the Rocky mountain juniper they do not overlap so closely.

The **giant arbor-vitae** (*Thuja plicata* Don.) (*Thuja gigantea* Nutt.): This tree resembles its eastern relative the arbor-vitae (*Thuja occidentalis* Linn.) very closely, both in appearance and in habits. (Fig.



11.) The cones are considerably larger than in the latter, and there are six scales that bear seeds, instead of four. Other common names for the giant arbor-vitae are red cedar and cedar. The leaves on the side branches are opposite, scalelike, about one-eighth of an inch long. They overlap very closely, and fall usually in the third year. The cones are one-half an inch long and ripen the first season. The bark (Fig. 11) is one-half to three inches thick, and is irregularly divided into broad ridges which have long shredded scales. The tree is said to resist fires fairly well, and can tolerate shade. It is not frequent in Montana, and is confined to moist situations on the western slopes of the Rocky mountains in



FIG. 12. Growth of young Rocky Mountain Junipers on the bank of Flathead lake, near the O'Brien mill. Photo by M. J. E.

the northwestern part of the state. It reaches its greatest development on the Pacific coast.

The Rocky mountain juniper, (*Junipers scopulorum* Sarg.): The Rocky mountain juniper is called frequently cedar or red cedar. It resembles its eastern relative (*Juniperus Virginiana* Linn.) though the fruit is larger and matures in two years instead of one. The leaves are opposite and do not overlap so closely as in the giant arbor-vitae. The bark is about one-half an inch thick and has thin shreddy scales. The cones, commonly known as "juniper berries," bear two or three seeds. This tree is common on the borders of Flathead lake, (Fig. 12.) and is found in various parts of the state.

The western hemlock (*Tsuga heterophylla* (Raf.) Sargent). This tree, commonly known as the hemlock, differs from its eastern relative (*Tsuga canadensis* (Linn.) Carr.) in having slightly larger cones with scales longer than broad. In the eastern species the scales are nearly as broad as long, and the cones have a stalk, whereas the cones of the western species are sessile. The leaves are rounded at the apex, flat, dark green above, white below, and have short leaf stalks, or petioles. The bark on full-grown trees is about one and a quarter inches thick and has rather



FIG. 13. Leaves and cones of the western Hemlock. Photo by M. J. L.

broad flat connected ridges with brownish scales. The tree, like the giant arborvitae, is very tolerant of shade. It is even more restricted in Montana than the giant arborvitae, and like it reaches its best development on the Pacific coast. (Fig. 13.)

The young trees of the Douglas spruce, lowland fir, Engelmann spruce and Alpine fir look alike to the uninitiated. The last named species is not often associated with the others, and hence is not so likely to be mistaken for it. The base of the leaf of the Engelmann spruce is woody, and remains attached to the stem after the leaf is shed, thus leaving peglike projections on the stem. The spruce can be easily distinguished

thereby from the other three trees. The western hemlock, however, has these peglike projections also, though they are not nearly so prominent. The leaf of the spruce is roundish in cross section, while that of the hemlock is more flattened. The leaves of the side branches of the lowland fir are dark green above and usually conspicuously notched at the end, while those on the side branches of the Douglas spruce are light

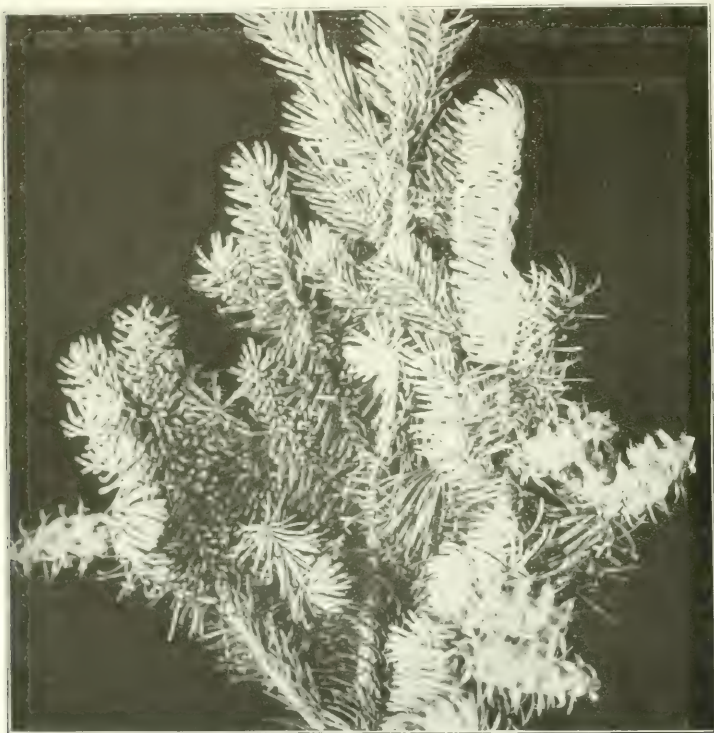


FIG. 14. Leaves and cones of Douglas spruce or lowland fir. Photo by M. J. E

yellow when young, usually dark green when older, and not notched at the end. The scar left by the former when the leaf is shed is round, while that left by the latter is more triangular in shape. The leaf of the former is sessile, and that of the latter has a very short leaf stalk. The cones of the Douglas spruce (Fig. 14) and Engelmann spruce hang down, while those of the firs are erect. The cones of the Douglas spruce have the bracts longer than the scales which easily distinguishes it from the Engelmann spruce.

The Engelmann spruce (*Picea Engelmanni* Engelm.): This tree closely resemble the white spruce of the east (*Picea canadensis* (Mill.) B. S. P.). Indeed the white spruce is said by some authors to be found in Montana, though others doubt its existence here. If it is found, it is difficult to distinguish it from the Engelmann spruce. The leaves on

the lower branches are usually short, stout, roundish in cross section, sharp pointed and a dark blue-green in color. They persist about eight years. The cones (Fig. 15) are about two inches long, sessile or very short stalked. At first they are horizontal but later drop. They mature at the end of the first season. The bark is thin and broken into large flaky scales. The tree on account of its thin bark, is easily destroyed by fire. It tolerates shade fairly well. It reaches its best development in moist situations, in swamps, along streams, and on moist hillsides. Outside of Montana it has a wide range in the western part of the United States and British America, usually in rather high altitudes.



FIG. 15. Leaves and cones of Engelmann's spruce. Photo by M. J. E.

The Douglas spruce (*Pseudotsuga taxifolia* (Lam.) Brit.) (*Pseudotsuga Douglassii* Car.): This tree, also known as the red fir, is neither spruce nor a fir, the name *Picea* being reserved for the former, and *Abies* for the latter. The word *Pseudotsuga* means literally "false hemlock," but the name has little or no significance.

The leaves of this tree have already been described. They remain on the tree about eight years. The cones, (Fig. 14) as already stated, are easily characterized by the fact that the bracts are longer than the scales. They vary in size from two to four inches. The bark (Fig. 7) of the tree varies greatly as the tree ages. In the older trees it is composed of large, broad, irregularly connected ridges. The bark is very thick at the base, usually from six to twelve inches, and even in excep-

tional cases two feet. By its thick bark (Fig. 7) the tree is well protected from fires. It does not tolerate shade. In this respect it may be compared with the western larch and lodgepole pine. In the Flathead valley the tree is associated with the western larch in moister soils and with the bull pine in drier soils. It does not, however, reach the dimensions here that it does on the Pacific coast, where, with the western hemlock and arbor-vitae, it forms luxuriant forests. The Douglas spruce is



FIG. 16 The Yew, showing leaves and berries. Photo by M. J. E.

distributed throughout the western part of the United States, but in dry climates it is small and stunted in growth.

The lowland fir (*Abies grandis* Lind.): This tree is also known as the white fir and the balsam fir. The leaves have already been described. On the horizontal branches they are conspicuously two ranked. They persist from eight to ten years. The cones are erect on branches near the top of the tree, and vary in length from two to four inches. The scales of the cones, as in all firs, are deciduous, the cone axis being shed later. The fruit matures in one season. The bark is smooth at first, with the characteristic balsam blisters. Later the bark splits into low

flat ridges, giving it the name of "rough bark fir" in some sections of the country. It is sometimes two inches thick, though usually thinner. The tree tolerates shade fairly well. It is not at home in the Flathead valley, though in favorable places it reaches comparatively large dimensions. Like so many of the other conifers it does its best on the Pacific coast. It is confined to low altitudes, seldom reaching above 3,500 feet.

The **alpine fir** (*Abies lasiocarpa* (Hook) Nutt.): This tree is also known as the balsam fir. The leaves of the lower branches resemble those of the lowland fir, though in trees growing side by side those of the alpine fir are narrower and lighter green than the leaves of the lowland fir. The cones are much alike also. The seeds have bright violet wings and can thus be easily distinguished from the pale colorless wings of the seeds of the lowland fir. The bark of the lowland fir is grayish or reddish brown, while that of the alpine fir is much lighter. The bark of the former is also much more ridged than that of the latter, which remains more or less smooth until very old age. The alpine fir, as its name implies, is a tree of the alpine regions. It does its best, however, in damp canyons, where it is associated with the Engelmann spruce. In the higher altitudes it is a companion of the white-bark pine on the exposed ridges, but is more at home in basins, occupying the places where the snow disappears first. It is found throughout the alpine regions in the western part of the United States, and reaches as far south as northern Arizona. (See frontispiece for characteristic locality for growth. On the extreme right is the tapering top of a beautiful tree.)

Daphnia Pond.

A STUDY IN ENVIRONMENT.

Morton John Elrod.

Daphnia Pond lies along the road about a mile and a half south of the laboratory. It is a small land locked pond, covering some 10 or 12 acres. It is undoubtedly of glacial origin, lying in a small pocket between two ridges of rock made by faulting. Its outlet in spring is to Flathead lake, a hundred feet lower in altitude. The pond lies in a glaciated region and is no doubt the result of glacial action. Within a few miles of Daphnia a dozen other ponds of similar nature may be found with similar origin, and offering the same field for study.

The pond is shallow at either end and 20 feet deep in the middle. The shallow places are overgrown with rushes, moss, water lilies, and other aquatic forms of vegetable life. A small place in the center has open free water. Around the banks there is the usual growth of willows, while numerous logs and dead bushes make the water difficult to reach. The bottom is largely of boulders, filled in between with mud, and overgrown with rank and dense vegetation.

The name Daphnia was given because of the great numbers of the entomostracan *Daphnia pulex* found in the pond.

Environment is a biological term having reference to the physical conditions affecting an organism. As referred to human beings we say the environment is good when the conditions are so favorable as to lead to good results. When a boy is sent to college he is in a good environment if his professors, his associates, his boarding house, and his companions all encourage him to such effort as will bring about the best results mentally, morally, and physically.

The environment may, of course, be bad. In that case the results are not what are desired. Bad companions and associates, bad tendencies, may bring about conditions of mind and body disastrous to the individual possessing them.

According to the best information we now possess, when an organism comes into existence it has certain hereditary tendencies. These are only tendencies, and are immediately intensified or diminished by the conditions in which it is placed. In addition to these hereditary tendencies each living organism has within itself, be they few or many, some characters which are called acquired characters, which originate within the organism, and are affected the same as hereditary characters. Often these are powerfully influenced by environment, are intensified to a marked degree, and apparently modify the entire life of the species and its descendants. Hereditary or acquired characters or tendencies, affected by environment, make the species what they are.



Daphnia pond, near the station. Note the hydrophytic vegetation with open water in the middle. Swan range in the distance. The view is north. Photo by M. J. E.

Environment may mean any of the following conditions: Physical conditions, temperature and moisture, so as to make food abundant and the conditions favorable to life. In such a case the species would multiply rapidly, with little tendency to variation from the normal condition. These conditions may be such as to make food scarce, make life a struggle, and kill off the great majority of the organisms of a species. In such a case there is marked tendency to variation. Those characters or traits most useful or helpful in the struggle will be selected, and organisms differing from their ancestors in some ways will be the result.

Again: in addition to the above two cases, and modifying either, there may be the presence or absence of natural enemies, which prey upon the organisms, increasing or reducing in numbers accordingly. Where food is most abundant and enemies practically absent there is great multiplication of numbers. Illustrations of these conditions are to be seen in America in the English sparrow, the San Jose scale, the codling and gypsy moths, and other noxious insects. Where food is scarce and enemies abundant there is either great variation or extinction of species, or both. Under such circumstances the struggle is keenest and most severe, those least able to survive are killed, and the resulting and living specimens are likely to be strong and hardy, unlike their ancestors, continuing to vary in structure so long as the hard conditions exist.

Let us make application of these principles to the life as we find it in Daphnia Pond.

Vegetable Life. Trees are absent. As no trees in the region other than willow shrubs can live in water the pond must be older than any trees growing near it.

When water collects in any place it is immediately invaded by certain forms of vegetable life, water plants. In sustaining life these plants begin to fill the pond. Their roots sink into the soil to hold the plant. Their stems become so thick and matted that whatever silt is brought into the water is held, and is not permitted to run out. The pond is gradually filled in, the plants in living, slowly make living impossible, and the result is the extinction of the pond and the death of both its animal and vegetable life.

Daphnia pond admirably illustrates the method by which a pond is filled. In the center is a small space of open water, twenty feet deep. This is bordered by a fringe of yellow water lilies, whose roots are deep in the mud, and whose leaves reach up through five or six feet of water to the surface. Among these are matted masses of lower forms of vegetable life. Outside, in shallower water, the rushes and cattails hold sway, their decaying leaves and stems each year adding to the decayed vegetable material. Nearer the shore the sedges have taken hold, and formed large hummocks, sufficient to bear the weight of a man. Along shore willows have taken firm hold on the soil.

This tangled mass of hydrophytic vegetation affords abundant hiding place for various forms of animal life, and at the same time supplies food for them, as testified by their great numbers.

The glaciated ridges adjacent have in very recent years been cleared

1917. A new vegetable growth is appearing, which may change the life materially.

Animal Life. Vertebrates are scarce in the waters of Daphnia pond. Fish are absent. This goes to prove that the pond has at no time had sufficient outflow to permit the ascent of fish from Flathead lake. Certainly fish could live in the water, since it is clear and cold, and probably has underground seepage. There is a good supply of animal food. Frogs are rather abundant, as are also garter snakes. The frogs prey upon insects, the snakes upon both insects and frogs. A dark green grass snake has also been observed. A single species of turtle has been seen, but they are rare. Among the rushes a few muskrat homes have been built, but the animals are scarce and shy.

The invertebrate life is abundant in numbers of specimens, but not in species. Three species of shells are found in the water, one on land. *Planorbis trivolvis* Say and *Sphaerium partumeium* Say are abundant in the hydrophytic vegetation. *Physa ampullacea* Gld. is rather common. *Pyramidula strigosa*, var. *cooperi* W. G. B. is found in damp places on land. It seems strange that but a single land snail has been found.

Among the entomostraca *Daphnia pulex* holds sway. So abundant is the species that the water in the open space near the center is colored a dull reddish brown. They may be taken in any quantity. Forbes reports that this species is probably a fish food. This may explain its scarcity in Flathead lake as compared with Daphnia pond. Forbes reported the species as absent from Flathead lake. It has been found by us in our studies each year up to present writing. Much less abundant, but still common, is *Diaptomus lintoni* Forbes, while in still smaller numbers is found *Cyclops pulchellus* Koch. *Gammarus*, probably two species, hide among the water lilies and rushes.

Insects are abundant. It is no doubt a breeding place for mosquitoes, although no larvae have been taken. Unidentified dipterous larvae in considerable numbers have been taken. No fewer than ten species of dragonflies have been captured on the wing. Most of these have also been secured in larval stage. Other material to be found in the pond in abundance may be mentioned; many beetles, two leeches, several case worms, many water bugs, diptera, and worms.

The vicinity of this pond is a great breeding place for birds. No fewer than forty-five to fifty migrants build their nests and rear their young within a hundred yards of the water's edge. For so small a pond this is a very good showing. On all sides the timber has been destroyed by fire. Thus most of the shelter formerly afforded has been removed. The nesting sites are confined to the low bushes along the water's edge, to those which have sprung up in the burnt area, to the dead boles left by the fire, and to the grass and reeds of the pond. Rails are heard daily as they move around among the weeds. Golden-eyes and grebes usually rear their young in the grass. Catbirds, western yellowthroats, flycatchers, chickadees, sparrows, juncos and woodpeckers, all are found. The tree dwelling warblers find a few trees near by. Kingbirds may always be noticed, noisily chattering as they leave their perches in pursuit of insects. The total number of species of birds observed in the

vicinity of Flathead lake as given by Silloway is 135. One-third of these may be found in the immediate neighborhood of this one small pond, showing the opportunity for study afforded by it.

Of the smaller microscopic life of the waters no examination has been made. Of protozoa, diatoms, desmids, and the smaller worms there is no doubt a large number owing to the abundance of entomostacan life which the pond supports.

Owing to the size and character of the pond it offers an admirable site for detailed study of several forms of animal and vegetable life with respect to environment, with opportunities for experiments in changing the conditions, thus vitally affecting the lives of the inhabitants. In comparison with the waters of Flathead lake Daphnia pond teems with life, although but a short distance from the former, and insignificant in size in comparison. In the large lake there is little protection along the shore, owing to the pebbly nature, almost none in the bottom. The vegetation is confined to a few areas at either end where shallow water makes a swamp, and where vegetation can have a footing. The water is clear, cold and deep. Receiving a constant influx of cold water from the Swan and Flathead rivers, the lake does not cool rapidly save in the shallow bays where the water has little motion. In Daphnia pond, however, there is abundant vegetation. Great mats of it may be pulled out from almost any portion, from the growing green plants uppermost to the dead and decaying peat below. This mass is alive with living and crawling objects, which here find ample protection. There are no fish to destroy them while in the larval stage, hence they multiply rapidly. Among insects many have been mentioned. As these emerge from the water to the air they prey upon each other, and are in turn preyed upon by birds. A bittern was killed with his stomach full of the dragonfly *Aeschna constricta*. Kingbirds are known to prey upon them also. There can be little doubt but that many species of birds live principally upon the insects about the pond, although no examination of stomachs has been made other than as above mentioned.

Daphnia pond is commended to the students of the station laboratory as an excellent place for securing material for statistical studies in variation, for determining the relationships of hydrophytic and hydrozoic life, and for experiments on both forms of life. It offers to teachers an admirable place for securing material for class use, being one of the best collecting fields discovered in this section of the state.

Types of Nests of Birds.

TYPES OF NESTS OF BIRDS, WITH SPECIAL REFERENCE TO THE
FLATHEAD REGION.

Perley Milton Silloway.

The nest-building habit of the birds is a marvel of inherited experience. Is it not remarkable that these feathered creatures of the air, roaming among the foliage of trees, bushes, or meadows for the greater

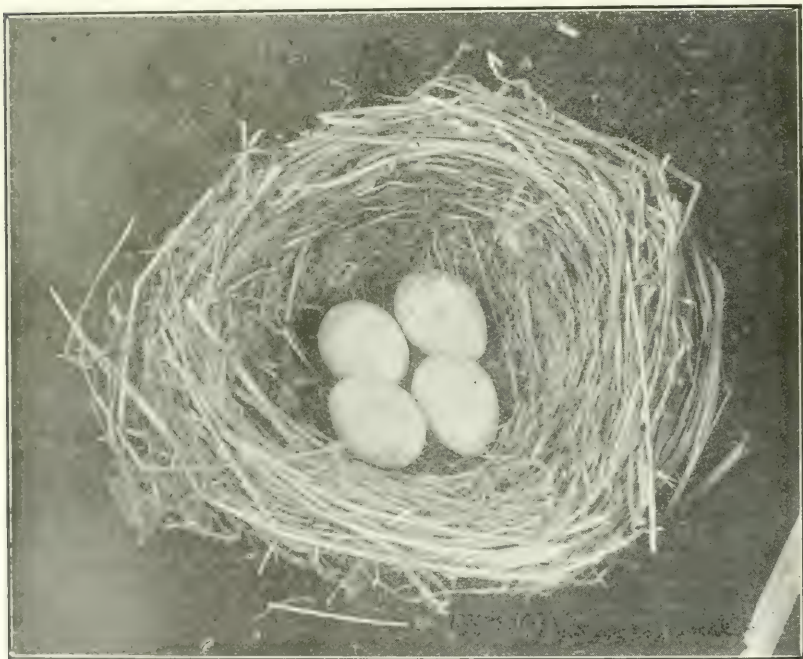


FIG. 17. Nest and Eggs of Olive-backed Thrush.

part of the year, should settle upon a particular site, and construct a habitation that often withstands the climatic vicissitudes of many seasons? We regard the cowbird as peculiar because of its habit of stealing among the bushes and depositing its eggs in the nests of other birds; but are not the other birds even more peculiar in their instinct of suspending their Bohemian habits for a short period, and settling down to the humdrum occupation of house-building and home-keeping? When we remember that for eleven-twelfths of the year the birds have no place of shelter

or retreat known as home, we may well wonder at the power of the impulse or instinct that leads them to build a strong dwelling for use but several weeks at most, and confine their activities to a limited range.

The knowledge of nest-building manifested by the birds is doubtless inherited. This theory is strengthened when we learn that birds of the same species construct nests of the same general type, following a common pattern of architecture and using materials of similar texture. A robin's nest in Montana differs in no essential feature of structure or material from one in Illinois or New York, and generation after generation of robins construct nests of the same typical style. If a robin be taken from the nest and reared apart from other robins, its attempts at nest-building will follow the plan approved by years of robin experience. Therefore when the bird-student becomes familiar with the type of nest constructed by any species of his avian friend, he will be able to identify the nest of that species thereafter with little difficulty.

After selecting a convenient crotch of some tree not far removed from civilization, the robin makes a substantial foundation of dried grass, strings, rags, or other similar material. Upon and within this Mrs. Robin erects a strong mud wall, smoothing it interiorly by rubbing and molding it with her breast. Then she places a bedding of coarse dried grass in the bottom of her cot, and she has a habitation as comfortable as a prairie settler's dug-out.

Among the nest-builders of the Flathead region, the olive-backed thrush is quite abundant. It selects a site near the top of a small fir tree, from six to ten feet from the ground, or in an upright crotch of a slender sapling, generally in the edge of a swamp or retired woods. The base of the nest (Fig. 17) is a loose mass of dried grass and weed-stems, upon which the builder forms a snug-walled structure of dark-green lichen and fine dried grass, the latter also serving as lining for the nest. It is said that in more northern localities a larger proportion of moss and lichen is used by this thrush, but the type of architecture is characteristic wherever the thrush is found nesting.

Belonging to the same genus as the olive-backed is the willow thrush. It is the rule that birds of the same genus have similar habits of nidification, but the willow thrush differs very materially from its congener in its plan of architecture. It uses very coarse weed-stems and strips of bark, pine needles, and dried leaves, all dark material, making a thick-walled cup generally deeper than the work of the olive-backed, lining it with dark root-fibers. This nest is generally placed on or near the ground, frequently on a heap of decaying leaves or similar rubbish. In 1902, however, a nest of this thrush was found six feet from the ground, in an upright crotch of an oblique sapling, a very unusual situation for the nest of the willow thrush.

The catbird is one of the common birds of this portion of the Flathead region. Its nest is made in a low bush, usually among upright stems. It is a bulky structure, also made of dark material. Like the willow thrush, the catbird uses strips of coarse bark, weaving them into a strong basket, which it lines with coarse rootlets. Pieces of dried leaves, and fragments of twigs are also used in the framework of the

radially's nest. In appearance this nest closely resembles that of the yellow thrush, though the different site in each case renders identification quite easy.

A type of nest radically different from any of the foregoing is presented by the American dipper, a bird which haunts the rapids of our mountain brooks, and plays in the splashing waters as they foam among the rocks or dash down the rock declivities. The nest of the dipper is a hollow ball of green moss, oftenest situated where it is kept soft and

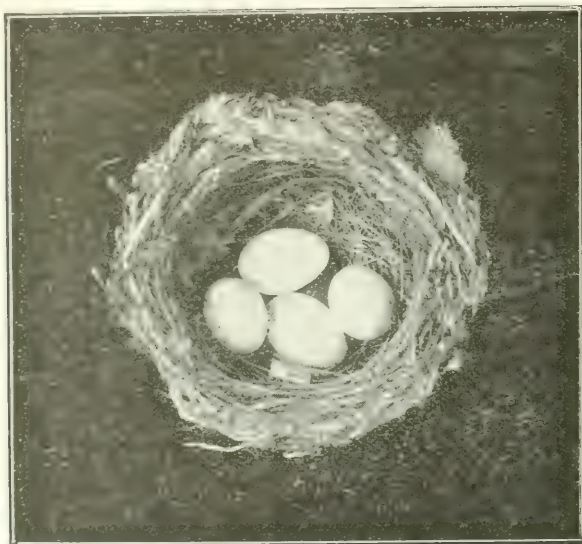


FIG. 18. Nest and Eggs of American Redstart *Setophaga ruticilla* L.

moist by the spray of rapids or falls, on a shelf of rock, or among the roots of trees washed by the brawling stream. On one side of this mossy, dome-shaped habitation is a circular entrance, and within it is an inner nest of leaves and grass. The site is nearly always among mossy surroundings, and the nest is easily overlooked by anyone not familiar with the nesting habits of the dipper.

Among the warblers of this region, the American redstart is a nest-builder of some note. It chooses dark gray-colored material (Fig. 18), such as fine strips of inner bark-fibers of weed-stems, bits of dark green lichen, flakes of gossamer, and fibrous grasses. These it shapes into a neat, well-rounded cup, fitted into some crotch formed by a small twig and a larger branch, generally upright, from six to twenty feet from the ground. In size the nest is probably the smallest among the warblers, and is difficult to detect in the gloomy light of the swamp-woods, as it resembles an enlargement at a joint of the branch.

The ground-dwelling warblers of this region manifest a great similarity of taste in their style of architecture. In this group are the western yellow-throat and Macgillivray's warbler, both of which make their

nests in grass tufts, about eight inches from the ground. The structure is made exteriorly of long pieces of grass stems, interiorly of fine dried grass, rootlets and horsehair. When made in a grass tuft among rank sprouts and small bushes, the nest of Macgillivray's warbler cannot be distinguished from that of the yellowthroat in similar situations. However, the yellowthroat chooses other sites, notably the rushes of ponds and swamps. In such situations the nest material is likely to be taken from that nearest at hand. A nest of the yellowthroat taken from *Daphnia*

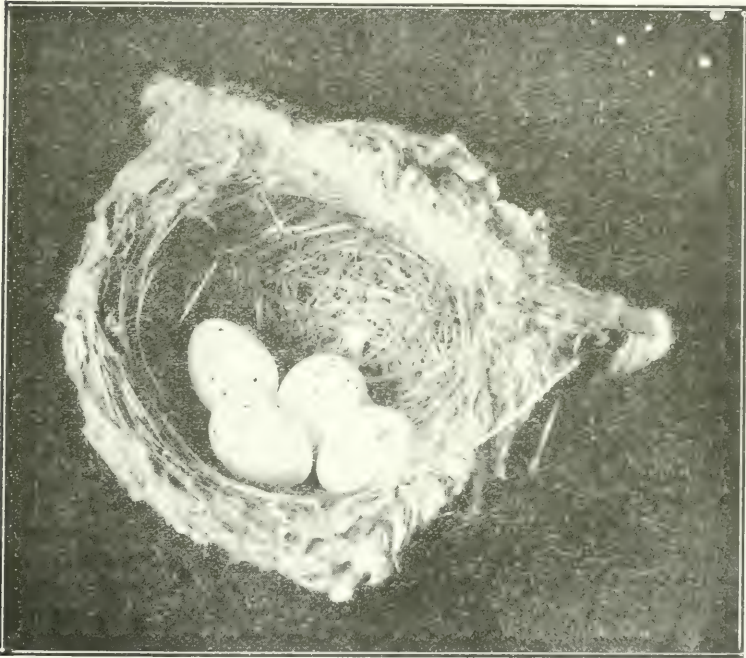


FIG. 19. Nest and Eggs of Warbling Vireo, *Vireo gilvus* Vieill. Photo by M.J.E

pond was made altogether of pieces of dried flag, with a lining of fine grass, thus resembling a cup-shaped basket of irregular weaving.

Though scarcely constituting a type, the nest of Audubon's warbler is somewhat different from other nests which it resembles. It is rather larger than that of the yellow warbler, and darker in appearance, assimilating more closely with its surroundings. Its outer appearance is much like that of the redstart, though it is so much larger that there is no likelihood of confounding the two. This nest is made of dark weed-stems, strips of weed-bark, gossamer, and fine dried grasses, with soft feathers and horsehair as lining material. The use of feathers in the inner wall serves to distinguish this nest from the work of the yellow warbler.

For neatness of structure and harmony of appearance, the nest of

the yellow warbler is a noteworthy example. It is usually made in an upright crotch of small branches, from five to fifteen feet from the ground. The materials chosen are of a grayish color. The predominating substance is fine dried grass, woven together with downy fibers, shreds of weed-bark, fragments of gossamer, and horsehair. The peculiar feature of this nest is the neatness of the interior finish. Frequently one is found that is lined throughout with white vegetable material as smoothly as if satin or morocco were used.

As a distinct type, the nest (Fig. 19), of the vireos is interesting in several ways. The site is unique, being invariably a horizontal or drooping fork of twigs near the extremity of a branch, from six to twenty feet from the ground. It is a swinging cradle firmly attached by its brim, without motion in itself yet swaying with every impulse of the passing breeze. The outer wall of the nest is very loosely arranged in an irregular covering of fibrous shavings, strippings of bark, gossamer, and pieces of hornet paper. The bedding of the nest is fine dried grass of a wiry texture. The foregoing description is alike applicable to the nests of the red-eyed and warbling vireo, the only representatives of the vireos in the Flathead region. The external materials of the nest of the red-eyed vireo is generally more loosely disposed, the cavity is somewhat larger, and the structure as a whole averages larger than the nest of the warbling vireo, otherwise no difference is observable.

In this locality the cedar wax-wing constructs a nest (Fig. 20), of an interesting type. It is generally placed near the top of a small evergreen tree, or near the extremity of a horizontal low branch of a larger evergreen. The foundation of the structure is a loose mass of dried grass and small twigs. The walls are made almost wholly of dark green lichen, pinned firmly together with pine needles and smaller twigs. Frequently the nest has a lining of fine wiry grass. This type of nest is characteristic of the cedar wax-wing in the northern evergreen forests.

One of the most abundant birds of this region is the lazuli bunting, the western representative of the familiar indigo bunting of eastern habitat. The nest of this bunting is made in low bushes, from two to five feet from the ground. It is a type in its simplicity, being made of coarse dried grass and weed fibres, lined with fine grasses and horsehair, the main elements being of a grayish white color. The walls are loosely woven, and the nest is rather large for the size of the owner.

The nest of the black-headed grosbeak is a type because of its loose arrangement and frail structure. The ordinary site is the top of a large, loosely-spreading bush, a small evergreen tree, or the top of a low thorn tree. In such situations the eggs can generally be seen from below, as the nest materials are so loosely woven that the bottom is comparable to a net of several folds to retain the eggs. The affair is made of dark-colored twigs and rootlets, and is usually lined with finer rootlets of a darker color, or with fine grasses of similar hue. Last season a nest of grosbeak was found lined with fine moss-stems of a reddish brown color, the effect being a very handsome nest. The nest is so frail that the materials readily fall apart, or the twigs drop away one by one.

The familiar chipping sparrow constructs a nest of simple yet original

pattern. An outer wall of finer weed-stems, grasses, or lichens, and an inner layer of horsehair, are the essential features in the chippy's idea of building at all times and places. The outer layer is variable or may be lacking, but the horsehair is indispensable, and frequently the nest

FIG. 20. Nest and Eggs of Cedar Waxwing, *Impeho redwornu* Vieill. Photo by M. J. E.



contains only this material. The chipping sparrow's habit of using horsehair has suggested its nickname of hairbird in many localities. Generally dark or black hair is used, but this season I found a nest in which white or gray hair was used, the only nest of the chipping sparrow thus finished that I remember to have seen.

Another sparrow of this region, the western vesper, follows a plan of building similar to that of the chippy. The site is a depression in the ground, at the base of a tuft or small bush. There is generally an outer

wall of dried grass or weed-stems, and a lining of horsehair. In many nests, however, the horsehair is lacking, fine dried grass being substituted for it, hence we see that the type is not so constant as that of the chipping sparrow. Moreover, the nest of the vesper sparrow is a very flimsy affair, held in shape chiefly by the cavity it occupies, and not likely to retain its form when removed from the site.

The nest of the black-headed jay is seen frequently in this region, along the mountain streams and lake shores. This nest is oftenest made in small firs, on horizontal branches against the main stem, from six to eighteen feet from the ground. A typical nest consists of an outer framework of coarse dried twigs, interlaid rather loosely. Within these is a layer made of coarse weed-stems and muddy moss or lichen. Internally there is a layer of coarse brown rootlets. One of these nests is about eight inches across at its top, and five inches high.

The nest of the American magpie is a peculiar structure, though interiorly it is very similar to that of its relative just noticed, the black-headed jay. The base is a mass of large twigs, which supports a basin of dried clayey mud from seven to ten inches in diameter and about six inches deep. Within this earthen bowl is an inner nest of coarse brown rootlets, frequently with a scanty amount of horsehair. Over the nest, at a height of a foot or more, is a thick canopy of dried sticks, forming a snow-proof covering. Around the sides is a lattice-work of stout twigs, frequently so closely interwoven that a regular opening is necessary for the the entrance and egress of the owners. Commonly, however, the birds enter through openings due to the loose degree of interweaving of the materials.

Among the nest-builders of this region, Wright's flycatcher next demands consideration. A typical nest is very similar to one of the yellow warbler, both in situation and construction. It is made of grayish fibers of weed-stems, shreds of bark, and gossamer, within which are woven small downy feathers and cottony materials, besides which a few fine grasses are frequently used as lining. The tiny feathers used in this nest aid in distinguishing it from the yellow warbler's, though sometimes a nest is found which is felted as softly within as some nests of the yellow warbler. See Fig. 21.

The woodpeckers, of course, nest in cavities which they make in the trunks of trees, at varying heights from the ground, and deposit their crystal white eggs on the bare floor of the cavity, making no attempt to carry material to complete the interior.

Most of the hawks and owls of this region seldom go to the trouble to construct a new nest, but usually take possession of an old structure made by some more industrious builder in a former season. The spirited little sharp-shinned hawk, however, makes a new nest each year, its habitation being quite typical. The site is low, two that I have examined in this region being each within eight and nine feet from the ground. The nest is a mass of twigs, having a very slight depression and no lining material to receive the handsome eggs which this hawk produces.

Among the water-birds of this region, the most characteristic nests are those of the grebes. These nests are made in the swamps, among

dead and growing reeds, in water a foot or more in depth. The nest is a mass of black, decaying material, intermingled with which is some green material of the season. This mass of rubbish is anchored among the reeds, generally forming a low mound projecting about four inches above

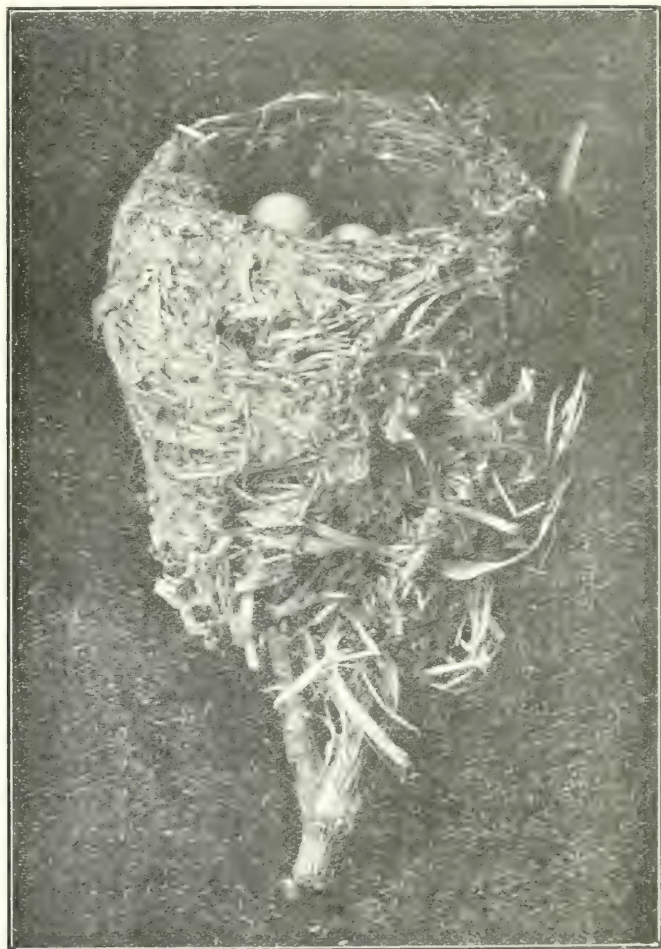


FIG. 21. Nest and Eggs of Wright's Flycatcher, *Empidonax wrighti*. Photo by M. J. E.

the water, and measuring from eighteen to twenty-four inches across at the surface of the water. The cavity is very slight, and generally contains a lot of loose stringy material like that in the nest, which can be hastily scratched over the eggs to conceal them when the owner leaves them.

Animal Counterfeits.

Maurice Ricker.

I have previously told of the marvelous adaptations of plants and animals. We have been duly impressed with the perfect harmony of adjustment and are prepared to examine into the more intricate relations existing between them. Let us keep in mind the universal struggle for food, the great loss of life in immature stages, and the tendency to variation. We believe that whatever variation tends to perpetuate the life of an individual, or to render it less liable to annoyance in procuring food, will prove of advantage to the race, since this variation tends to be transmitted to the offspring.

Truly, might an animal exclaim, "This is a world of shams." "Everyone is seeking to deceive." Aesop's fable of the "Ass in the Lion's Skin," is a tame story compared with the one we may see in nature any summer afternoon. For, in the fable, the ass masqueraded but for a day while in nature we find animals whose ancestors, for a thousand generations, have carried out their hypocrisy for a life time.

The simplest example, and one which every one has observed a great many times, is called protective coloration. Upon the success with which an animal can become apparently a part of the general landscape depends his very existence. The lessons we have all had when seeking some wild animal have fixed this principle well in our minds.

I remember once seeing a young spotted sandpiper on a rocky sandbar in a small stream. I went over to pick him up, when, as if by magic, he disappeared. In vain did I search and, for all I know, the little rascal is hiding there yet. He was no doubt sitting motionless among the rocks, and my eye was not keen enough to discern him among the light and shade of the pebbles. If animals are not wholly devoid of humor, what a good joke it must be—this game of hide and seek of theirs.

But it is serious business. It is in reality a game with the player's life at stake. If he wins he lives to perfect his art and practice his profession of a counterfeiter. If he lacks confidence in his own game and betrays by a move the fact that he is not a part of the inanimate landscape, he pays the penalty with his life. If through variation he happens to be more conspicuous than his type he stands a much greater chance of being picked up by his enemies. Thus nature would check a tendency to more conspicuous colors.

A few words on color in general may not be out of place. Scientists now find significance in nearly all coloration. At one time it would have been sacriligious to have found other reasons for nature as it is, than as a creation solely and wholly for man's pleasure. I, for one, do not believe that man's reverence for nature or nature's God is any the less deep, for what may be called a more modern view. The true dignity of man and his exalted place in the universe is not lowered by this conception



Mimicry of *Anosia plexippus* (upper) by *Basilarchia disippus* (lower).
Photos from water color drawings by Mrs. Edith Ricker.



Bumble bee (above) mimicked by fly (below) Photos from water color drawings by Mrs. Edith Ricker.

of the organic world. A hundred years ago they said the hills are clothed in green and the valley bedecked with flowers solely to please man's eye for color. The poet says that "Full many a rose is born to blush unseen, and waste its sweetness on the desert air." I take it that the relations of plant and insect life thousands of years before man's appearance on the globe were much the same as to-day, and that an intelligent understanding of these facts will add largely to man's enjoyment of nature. Is not the pleasure of intellectual insight into nature of even higher order than the gratification of the sense of sight and smell." So color must be studied with the good of the race always in view.

In general animals wear colors that harmonize well with their surroundings. This arrangement may serve one of two important purposes and sometimes both. The most obvious use is that of the case just cited, where concealment is most desirable and necessary for protection of the animal sought by stronger animals for food. The other case is easily explained in the case of the polar bear. He has no enemy but hunger and his coloration enables him to steal upon his prey unobserved.

The advantages of protective coloration are still more clearly brought out by the examples of those animals which change their color with change of season. The Rocky Mountain goats live always on or near the snow. They remain white throughout the seasons but the ptarmigan changes to match the ground in summer and the snows in winter. The weasel and many other animals change their coat with the seasons.

We find in insects some of the most marvelous instances of coloration. It is well known that green larvae usually feed upon green leaves and brown larvae rest upon brown stems. The cocoons of moths are sometimes wrapped in leaves and the naked chrysalids of various butterflies resemble dried leaves. The common walking stick, as it is well called, while a common insect of the field is seldom seen owing to its almost perfect resemblance to the twigs upon which it rests. The measuring worms, as they are called, more properly the larvae of grometrid moths, have not only the color of the plant upon which they rest, but when disturbed they hold to the stem with their abdominal feet, and, stiffening themselves at an appropriate angle to the stem, look precisely like the petiole of a leaf or a broken branch. It is a truly interesting experiment to tap a plant upon which they are feeding and note how rigid they become and how perfectly they assume the proper attitude. After a few minutes they will slowly unbend and become living larvae once more. Who has not walked through a forest and seen the brilliantly colored catocala moth flit an instant before his face and apparently disappear when he alights upon the tree trunk? As interesting a disappearance is that of the coralwing locust who flies with a gaudy flash of red or yellow and drops into the dust in the road to all appearances as lifeless as the clods around him. It is often necessary to scare him up many times before you are able to detect the dust colored form crouching in the dust, ready for a spring. So we might continue to name hundreds of familiar cases of protective coloration among animals. Besides, especially those birds which nest on the ground are protectively colored. We have all experienced the thrill of seeing a nighthawk get up from under our feet. You may

have scatched the ground in vain for the speckled eggs laid so openly on some bare rock with the same lack of success that I have had.

I want here to mention some points not always understood. It is not supposed that the lower animals use cunning in their counterfeiting. We consider rather that they are unaware of the part they play. They certainly have no intent to deceive and are many times not conscious that they have any advantages in concealment. The chameleon changes color to suit the color of the substance it nests upon as nearly as possible, without conscious effort. By destroying his brain with a wire and then placing him on the colored backgrounds, this has been proven to be a reflex action.

The young robin instinctively remains in the posture I place him in, no matter how uncomfortable it may be. The nighthawk flops around and leads us away from her nest with no more thought than when she formed the blotched eggs which are so difficult to see on the ground. This leads up to a consideration of instinct and animal intelligence which must be deferred to another time.

Under the head of protective coloration are the many instances of warning coloration. Here the animal seems made for show and certainly intends to be seen. His colors stand out brilliantly; and as fitting actions accompany coloration we notice in this class of animals a disdain of concealment and often, in the case of flying insects, a loud buzzing noise. The bumble bee goes about its business and makes all the noise it pleases; in fact, seems to announce its coming.

As an example of warning coloration notice the orange or yellow banded bumble bees. If you are in doubt as to whether they need to conceal themselves catch one of them in your fingers and learn wisdom. If you need further experimentation next try the orange banded hornet. It may be difficult to teach one who has tried these experiments that these animals are well behaved, peace loving citizens of the insect world. If you stop to reason you will perceive that you were the aggressor in this instance and that you have hitherto carefully avoided thousands of these yellow or orange banded insects flying around with a buzzing noise. These insects are not armed with the intention that they are to use their weapons frequently. The occasional one who is imposed upon teaches the rest of the animal world to leave all similarly uniformed insects alone and as a rule they go on their way unmolested and to these colors owe their freedom from annoyance. Other insects like the brilliantly colored beetles and the Anosia butterflies are very distasteful to birds and their other enemies. Unless a bird inherits a suspicion against them he will soon get a bad taste in his mouth that will remind him for all time of its source. Certain caterpillars are likewise protected. Our common potato bug has few enemies after it hatches into the larva stage. If it were so fortunate with respect to its eggs it would no doubt exterminate the potato plant.

A very strangely marked blue frog of the tropics was placed before a number of cautious fowls. After a time an unsuspecting gosling took a number of cautious fowls. After a time an unsuspecting gosling took for some time shaking its head and evidently very sorry for its error.

Among mammals the skunk is a strikingly colored as well as a strongly scented animal. But why tell of warning coloration in a study of counterfeit? You say surely the bees are an honest self respecting folk. So they are, but we must understand what freedom from annoyance or extermination they enjoy and then we are fully prepared to comprehend the beautiful scheme by which nature protects her own from her own. Let us look for a moment at the *Anosia plexippus* (Plate L.) a butterfly of tropical origin, which migrates northward in the spring time, lays eggs for a spring brood which complete the cycle and migrate further northward. The fall brood migrate southward in September. There is no easier butterfly to raise from the egg which may be found on the common milkweeds. Why does this butterfly enjoy such a freedom of flight? It is found upon trial that birds forcibly fed upon the adult *Anosia* become very sick. It would seem that the birds have either tried the experiment or are warned in some way from doing so. They therefore never touch brown butterflies of this size with a black bordered wing bearing a row of white spots.

Let us now look at representative members of a widely separated genus, the *Basilarchias* (Plate L.) We find them to be generally purple in color with white or brownish markings. The common species of this genus in Montana has a broad white band on the forewings. In habit they are shy and flit from one bush to another.

One species of this genus differs radically from the others in coloring and habit. It is the species *disippus*. It is almost a perfect copy of the *Anosia* just described. It also has the habits of that insect. The early entomologists, who made the classification a matter largely of external appearance, very naturally classified the two together. In fact they are so nearly alike that they deceive everyone but the trained entomologist who looks beneath outward appearances. They differ in that the *Basilarchias* are edible when birds can be induced to try to eat them. This is doubtless a very rare occurrence in nature owing to the perfect resemblance to the undesirable species.

Wallace states the conditions necessary in order to effect mimicry are follows:

1. The two species, the imitating and imitated, must occur in the same locality.
2. The imitating species must be the more defenseless.
3. The imitating species must be the less numerous.
4. The imitating species must differ from its allies.
5. The imitation is external only, affecting only external appearances.

As to the origin of such a species some think that it must have come from *Basilarchia astyanax*, the common species of the middle states, which is sprinkled with brown spots. It may be that certain individuals differed from the current stock in being nearly or entirely brown. A sudden variation to a widely different type is called a sport and occurs in all species. If the sport came near enough the *Anosia* in color to be mistaken by its enemies for an edible species, it would be likely to live to reproduce. From the eggs of such an insect perhaps only a few would resemble the parent but these few would stand the better chance of

living and eventually would become distinct, owing their very existence to an accidental similarity of sports. Each generation tends to make the resemblance greater as the unprotected ones would be more likely to be eaten by hungry birds. We therefore call this a case of insect protective mimicry. It is probably the best case known. The manner in which the species arose teaches Darwin's great doctrine of the survival of the fittest and explains what he means by natural selection. Without this great key to the secrets of nature before the time of Darwin man was unable to explain many great biological problems, as for example the existence of related species and the enormous waste of life in arriving at maturity. The law of survival of the fittest solves to the satisfaction of many these great problems. The animal takes no conscious part in the great scheme of nature. It takes no thought as to how it is clothed or fed. The unalterable laws of the universe are at work upon it, but it need not know or care.

Another line of counterfeits of very great interest are the numerous unarmed insects who wear the uniforms of the wasps or bees. We need not go into the subject very deeply since it is almost a parallel case to the one given at length above. It is of obvious benefit to a defenseless fly to wear the yellow sash of a bee and thereby escape attacks of enemies which fear the sting of the bee. Many such can be found on the flowers almost any sunshiny day in summer. There is a family of flies that especially enjoys this disguise and feeds on the nectar of flowers, sucking through their long slender probosces. Since they aid in cross-fertilization as much as would a true bee I do not know that we should condemn their deception too severely. We may look upon them as harmless masqueraders.

While we admire the cunning in nature which protects so many helpless and innocent ones from injury, what shall we say of those rascals who wear the uniform of the bee, not for protection to themselves, but for the purpose of being better able to steal upon their victims. Many a tragedy in insect life occurs in about this way. A strong two-winged fly looking very much like a bumble bee in size and color and differing slightly in the buzz of his wings alights on a clover blossom and settles down to await a victim. Soon a heavily laden bumble bee alights upon a neighboring clover head wholly unsuspecting the counterfeit bee on the other blossom. Like most honest people he has little time to harbor suspicion of evil from one of his own kind. The villain squares himself for a jump through the air. A second later he alights upon the back of his victim. He holds the dangerous abdomen with its deadly sting securely in his bristling legs, and punctures with his strong beak the shiny armor on the bees thorax. In a minute it is all over, and, dropping the lifeless victim, he begins to clean himself after the manner of the fly family. I have his picture for the rogue's gallery. (Plate LL.) See how much like a bee he is even with wings and legs spread to show the differences. Gibson has told the Syrphus fly story especially well in his "Sharp Eyes." There is a large number of the robber flies who mimic for aggressive purposes.

Why are all small boys afraid of a dragonfly? The boy believes the

real mission of the dragonfly in life is to feed snakes and sew up the eyes, ears or mouths of small boys? Catch a dragonfly or a crane-fly or any other insect with a long abdomen and how does he act? It turns the abdomen around wasp like and pretends it will sting. The boy believes the dragonfly will sting. Later in life he learns that the insect is perfectly harmless.

Among caterpillars there are many amusing instances of larvae being provided with means of putting on a horrid face or swelling up in such a way as to strike terror to the heart of all but those who know his ways. Snakes coil as if to strike, dart out their little forked tongues and look very vicious. Butterflies have big eyes on their wings giving them the appearance of larger and more ferocious animals. There are thousand of instances in which the animal, while perfectly harmless, deceives the uninitiated into believing him a very ferocious beast.

I sometimes think of the swagger and bluff of the biped coward who assumes the role of "a bad man." He may be pretending to be just spoiling for a fight. The fact is wild animals put up what we call a bluff. Some will fight a wicked battle when opportunity offers, but in general they want to be let alone. The rattlesnake sounds his warning. His rattle serves to protect him by frightening away more enemies than he fights. The armed bees carry warning colors and wish to be let alone. The mosquito seems an exception to this rule, but only the female, seeking nourishment for her brood that is to be, bothers man. Another series of counterfeiters that I must expose are those who by some display simulate the food of animals and the victim discovers his mistake just in time to be himself eaten. The kinglets and fly-catchers among birds as well as certain fish display traps of this kind. The term alluring coloration is appropriately applied to this class.

The fish bury themselves in the mud and by moving certain appendages lure smaller fish to believe that there are edible worms to be had in that vicinity. Upon attempting to obtain them they are themselves eaten.

The crowned kinglets and the tyrant fly-catcher spread a crest of orange or ruby feathers in a way that attracts flying insects to the supposed flowers. I have observed the ruby crowned kinglet engaged in attracting insects by this device. It seems to work well in early spring when both flowers and insects are scarce.

I have purposely reserved to the last an illustration in protective coloration that excells them all in the wonderful detail with which it is worked out.

Sir Alfred Russell Wallace, the naturalist who shares with Darwin the honor of discovering the theory of natural selection, on a visit to Borneo was told of two strange butterflies. One grew on trees and could be occasionally found apparently attached to the limb. The other was a brilliant blue and orange insect that totally disappeared when it flew into the shade of a tree. As you have already discerned, Wallace soon found them to be the same form and he gave to the world the example of the Kalima butterfly.

Words can not adequately describe this marvel which must be seen in its natural size and color to be appreciated. The wings told in such

a way that the tips of the hind wings touch the twig, giving it the appearance of an attached petiole. The outer border resembles that of a torn leaf. Running up the middle of the folded wings is a dark line which represents perfectly a midrib. It has a raised appearance given by an artistic rendering of light and shade effects. One can scarcely believe that it is an effect produced by flat scales.

Still more wonderful is the way in which the venation of the leaf is brought out. The natural color of the veins is heightened in the two quarters where wing veins would harmonize with leaf veins. Still more wonderful is the almost total suppression of the wing veins in the other two quarters where wing veins would run across leaf veins; but in their place, to carry out the deception, it would seem, to the minutest detail, a series of shadowy scales take the direction of leaf veins. Thus the pattern of leaf venation is completely represented. The leaf insects, leaf carrying ants, and all the long list of nature's deceivers, must yield the palm to the magnificent Kalima butterfly, the prince of counterfeits of the animal world.

Thus nature strives to protect her own. The key that unlocks many a mystery in animal adaptation is not always easily found. Working upon the hypothesis that animals have come to their present forms and colors through adaptation to their environment we believe that there is sufficient reason for all phenomena. We have the privilege here of working in nature's own laboratory where as yet the hand of man has hardly disturbed the balance which has been brought about by years unnumbered. A few years more and where can we find a spot on this hemisphere where man has not turned the plant and animal world topsy-turvy by destruction of native species and the introduction of foreign ones. Let us then improve our opportunity.

The Forest and the Prairie.

Harry Nichols Whitford.

Plants may be divided into two groups, herbaceous and woody. In the former the part above ground dies in the unfavorable season; in the latter the part above ground does not die annually. These two general forms may be subdivided. For example, the herbs may be divided into annuals and perennials, and the woody type may have the form of the shrub, vine, or tree. The climate of the greater part of the state of Montana is more favorable to herbaceous than to arboreous plants. The portion of the state east of the Rocky mountains is primarily a region where the moisture conditions will not permit trees to grow. However, there are certain parts in which the rainfall is sufficient in quantity to favor the growth of trees. The northwestern portion of the state, embracing the Flathead valley and the mountains on each side, is an extremely favorable place for the production of forests, but parts even of the Flathead valley are incapable of supporting trees. On one side of the valley, the prairie side, the rainfall is less than sixteen inches. The forest side has a rainfall of about twenty-one inches.

In order to understand why trees are confined to certain regions, it is of extreme importance to know what functions they perform and how the conditions in which they grow affect the work they do.

The tree absorbs water. It does this through its root system, and the greater the root system, the greater the power of absorbing water. The tree with an extensive and deep root system can live in drier situations, other things being equal, than the tree with a shallow root system, for its roots come into contact with more water in the soil, and in some cases may reach to the underground water level. In the latter case it is not so dependent on the amount of rainfall. Where the underground water level is near the surface, trees with shallow roots have as good a chance to get water as trees with deep roots. To illustrate these two points, compare the **bull pine** and the **silver pine**. The former has a deep and wide spreading root system. It can grow in much drier soils than the latter, which, on the other hand, has a shallow root system. It is, as a rule, confined to those situations where there is a great deal of water in the soil. Again, the root system of a tree serves to hold it in place. Those trees with deep root systems cannot be blown over so easily as those trees with shallow root systems. In the Flathead valley it is not an uncommon thing to find silver pines lying prostrate with almost their entire root system exposed, while other trees in the same situation are able to resist the wind because they have deeper root systems.

The tree is using water continually for three purposes:

1. Small quantities are used to supply the new growth that is added to the tree annually.

2. Small quantities are used in the manufacture of foods, such as starch, sugar, and other carbohydrates.

3. Large quantities are used to supply the loss by evaporation that is continually going on.

Analysis of the last process will show what role it plays in the distribution of trees.

The evaporation of water from plants is known as transpiration. The water taken in through the roots is carried through the stem to the leaves and other superficial parts of the plant, whence it passes into the atmosphere as vapor just as water in any moist object may. Other things being equal, the greater the surface a plant exposes to the atmosphere, the greater the amount of water given off. The tree, because it has a greater surface exposed than other forms of vegetation will give off more water. A birch tree with about 200,000 leaves has been estimated to give off from 350 to 470 pints of water on a single hot day. The amount of transpiration is regulated in a great measure by the conditions of the atmosphere. If the atmosphere is damp there is less transpiration than when the atmosphere is dry. Again, on a windy day the tree will give off more water than on a still day. Other things being equal, more water will be transpired on a warm day than on a cold day. Indeed, any condition that will affect the evaporation from wet objects, like clothes on a line, will affect the transpiration of a tree. In the growing season a tree like the birch will give off more water than a pine or fir tree of equal size, for the birch exposes to the air more leaf surface than the pine or fir; also its leaves are more delicate in structure than their hard needle-like leaves. Therefore the pine, other things being equal, can live in situations, which are drier during the summer months than can the birch. However, during the winter season the birch having shed its leaves exposes nothing but bare limbs to the atmosphere, so transpiration is much reduced. On the other hand the pine holds its leaves and has as much surface exposed during the winter as during the summer, and it is therefore in more danger then of losing water than a tree without any leaves. For even though the loss be checked by cold weather, absorption is checked also, because the colder the ground, the less the absorption; and if the ground be frozen around the roots, little or no water can pass into the tree.

It will be seen from the above that there is a relation between the intake and the outgo of water from the tree. If the tree is to survive, absorption must be greater than transpiration. As soon as it is equal to or less than the transpiration, the tree is in danger of drying out. In those climates where the rainfall is not sufficient to keep the soil wet enough to maintain this inequality between absorption and transpiration, trees cannot exist. But even in prairie regions there are places where there is sufficient water in the soil, as is the case near bodies of water where the underground water level is near the surface. This, no doubt, accounts for the presence of trees along streams in climates where the rainfall alone is insufficient to maintain trees.

Trees, being green plants, manufacture starch, sugar, and other carbohydrates. They do this in all green parts and therefore mostly in

the leaves. Water taken in through the roots is united with carbon dioxid absorbed from the air through the leaves. In the presence of light, by an unknown chemical process, the carbon dioxid and water are changed to a carbohydrate and oxygen is given off. Of course, light reaches the trees only in the day time. This process needs a certain amount of heat, but small quantities of starch can be produced by trees with evergreen leaves even at temperatures slightly below freezing. There are probably many warm days during the non-growing season when considerable quantities of carbohydrates like starch and sugar can be made. Especially would this be true in the early spring and late fall. The trees with broad leaves can manufacture more food during the summer months than trees with needle leaves, for they have more surface exposed to light, and the greater the green surface, other things being equal, the greater the amount of food that can be formed. But the time for the making of food by these broad leaved plants is practically limited to the time of the year during which they have their leaves. As soon as the leaves are shed little or no food can be produced. Thus, while they have an advantage over the evergreen trees during the summer, the latter, because they can work more or less during the whole year, may manufacture more food in a year than the former. This is more likely to be the case in high latitudes where the temperature of the summer months is comparatively low, than in more southerly climates. Especially is it the case in climates with a more equable distribution of the heat throughout the year, the summer months having a comparatively low mean and the winter months a comparatively high mean. Such is the climate in the Puget Sound region, where conifers are developed best in America. In the Flathead valley the distribution of the temperature throughout the year is not so equable as it is in the Puget Sound region, but it is more so than in a similar latitude in the eastern part of the United States. The evergreen trees reach a more luxuriant development in this valley than anywhere in the east, but of course are not so luxuriant as in the Puget Sound region.

The greatest danger that trees have to meet is an excessive loss of water. They are excluded from those climates that have little rain fall. A prairie vegetation can exist in these places because the plants growing here have met the danger of drought better than trees. There may be climates where the rainfall is so little that even prairie plants cannot thrive; then a desert is the result. There is, however, no true desert region in Montana, although in places it approaches the desert condition. These regions are known as the **great plains**. In such regions the sage brush is a characteristic plant, although it is not so conspicuous an element there as in the more desert like regions.

When the climate of a country makes conditions favorable for a certain **form** of plant life, then that **form** gives character to the landscape. If the grass and its associates give character to the region, then there is a **prairie formation**. If trees give a tone to the landscape, then there is a **forest formation**.

It may not be out of place to compare the relative capacity of these two forms of plants (the grass form and the tree form), to meet this

danger of too great a loss of moisture. The danger to plants becomes greatest during the dry summer months and during the winter. As already shown, during the winter months the cold soil is not favorable to absorption, and if the plant be subjected to evaporation then, it is likely to transpire more than it can absorb. A cold soil then acts in a measure like a dry one, and the plant is in danger of excessive loss of water during the winter as well as during the dry summer months.

The herbaceous plants meet the danger of transpiration and freezing by dying down to the ground during the unfavorable season. The annuals of course are tided over this season in the form of seeds, and the perennials, beside seeds, have also underground stems. The latter, because they are protected by the soil, are in little danger of drying out. The woody plants, on the other hand, are exposed to all the extremes of winter. All trees are protected by their bark. In the young twigs this is not so thick, and hence these parts are more exposed than the older parts with heavy bark. So it is with the seedlings; for, although not so exposed as the older trees, the seedling stage of a tree is the most delicate one in its existence. If the dry season comes on before its root system is well developed, the seedling is very likely to perish. The seedling is subject to other dangers that will be mentioned in another connection. Those trees that shed their leaves are not so exposed during the unfavorable season as those that have their leaves the year round. Even the trees without leaves may be winter-killed. On the whole, then, herbaceous plants are less exposed during the dry and non-growing season than the trees.

Fires are detrimental to all vegetation, so it will not be out of place to compare the two forms with regard to their powers in resisting fires. A fire sweeping across the prairie may burn the surface clean of vegetation, but seldom if ever injures the underground parts. As soon as the season permits, the grass will spring up from these underground stems. Trees that have the power of developing suckers from roots will be protected in the same way. But few conifers have this power. However, the bark of old trees is often a protection against fires. The bull pine, Douglas spruce and western larch have thick bark and are protected in this way from fires that are not too intense. Young trees, however, succumb even to light surface fires, so acres of young trees may often be destroyed by fires that will not injure the older trees. The perennial herbaceous plant, then, has greater powers of surviving fires than trees.

Again, grazing animals are injurious to vegetation. The perennial grass is protected, because, when the top is eaten off, the under ground part is usually uninjured. Of course, if the above-ground green parts are eaten off so frequently that they have no opportunity to manufacture new food, the plant will be killed, and when the food stored in the underground stems is used up, then the plant will starve. Hence close pasturage is dangerous to the grass form. However, other forms of herbaceous plants that have an objectionable taste or are covered by spines or prickles will be avoided altogether by the grazing animals, or eaten only when nothing else is available. Sheep are the most destructive ani-

imals to pastures. The grass type has an advantage over some other forms of herbaceous plants in another respect. The growing region of a grass leaf is at the base, often below the surface of the ground. This part is less likely to be injured by fires or by grazing animals. As soon as the danger is passed, growth is resumed if the other conditions are favorable.

Young trees are subject to destruction by grazing animals. Especially is this true early in the spring, in the late fall, and in winter, for then there is often little to eat. Trees with needle-like leaves are protected more or less in that the needles, acting as prickles, are disagreeable. Yet even the shoots of conifers are often eaten. Young trees of bull pine and Douglas spruce have been found thus injured by cattle. Herds of cattle and sheep kill many trees in the young stages by trampling them. The older trees are less likely to be injured by grazing animals than the younger. The most important growing parts of trees, unlike that of the grass leaf is at the tip of the young shoot, and as this is the most tender as well as the most exposed portion it is likely to be eaten, by which the tree may be damaged or killed.

From the above it will be seen that the young tree is more subject to drought and is more likely to be destroyed by fire and by grazing animals than the perennial grasses and other herbaceous forms that grow in the prairie. In the drier regions, then, the prairie forms can exist where trees cannot, and even in regions where the moisture is sufficient to make tree growth possible, the occurrence of fires and the presence of grazing animals may favor the prairie rather than the forest. Of course, the forests that border on the prairie are open and prairie plants can exist there, but where the forest forms a heavy canopy, nearly all grasses are excluded, for as a rule, they require more light than they can get in the deep shade of the trees.

It should be emphasized that the seedling stage is the most critical period of a tree's life. Probably many trees could exist in drier regions than those in which they are found, if they could survive the juvenile stage. Especially would this be true of those trees that have deep and widespreading root systems, for they might later be able to get a sufficient supply of water from the soil to supply the excessive loss by transpiration. A number of successive favorable seasons no doubt permits some trees to be established in places where otherwise it would be impossible for them to get a start.

Another factor that is against tree growth is the prevalence of wind. Of course, occasional violent storms may destroy forests. But since on a windy day there is more water given off than on a still day, even moderate winds may be prohibitive of tree growth whereas the occasional storm only partially destroys it. Because this factor is not so obvious, it is often overlooked. Even if the rainfall is sufficient to support tree life, in regions of excessive wind trees are often absent. A good sample of this is found in contrasting the two sides of the Rocky mountains. At the east base of the mountains where the Great Northern Railroad crosses, there is a rainfall of twenty inches or more, with little or no tree growth. The west base in the Flathead valley with a rainfall of ap-

proximately twenty inches bears a luxuriant forest growth. In the former situations, the winds are excessive. In the latter, they are neither as frequent nor so strong.

From the above it will be seen that the main cause for the absence of trees in a greater part of the state of Montana is the lack of sufficient moisture. In some places, however, where there is sufficient moisture, winds, fires, and grazing animals may prevent the growth of trees and thus favor the prairie.

Montana Shells.

NATURE STUDY LESSON.

Morton John Elrod.

The state of Montana is not very productive of conchological specimens. The conditions are all against shell growth. The rivers are rapid, the water quite soft, and food in the rivers scarce. The large lakes, as Flathead lake, contain clear, cold water. They are usually deep, with rock bottoms, and surrounded by mountains with steep slopes. The marshy, stagnant parts of the lakes are usually small. The mountain sides in summer become dry and parched, except in protected portions and along streams. Great stretches of plain are without moisture for a portion of the summer, drying up almost every living thing that cannot move to the water-courses. The days are hot, the nights cool. In this mountainous state, where very little soil is lower than 3,000 feet above the sea, the air is dry and evaporation rapid. A passing rain cloud may leave considerable moisture, but it is soon taken up by the parched earth or evaporated if left on the surface. Stagnant ponds with decaying vegetation are few and confined to the vicinity of a few rivers. Even such ponds usually become dry each summer.

Most of the valleys were former lake beds of greater or less extent. As these lakes have been drained, they left swamps in which rhinoceroses, camels, three-toed horses, elephants, titanotheriums and other beasts became mired, their remains being buried for long ages. These swamps have dried up, and the waters have become more widely separated, now occurring as deep mountain lakes, or larger lakes, which are mere expansions of rivers. Such isolation must have caused the separation of shells of a species which naturally would take different lines of development. Accompanying this gradual separation of waters we might expect a region of moisture on the land adjacent to the lakes, giving suitable environment to the land snails.

As a result of the above conditions, we may expect great variations in adjacent regions, where the barriers may be sufficient to cut off all communication. There is very little doubt but that the isolated lakes in Montana and the northwest will produce interesting variations. But the sparsely settled country and the small number of collectors make the work of collecting and studying very slow.

The lack of lime in the waters of the state in considerable quantity is another element contributing to the paucity of shell life. Specimens taken from water invariably have thin or frail shells. Some are exceedingly delicate. The land forms, although not numerous in species, have thicker and heavier shells, affording much better protection. One species of slug, without a shell has been taken, but in small numbers.

In considering the above conditons it is apparent that collecting living shells is confined largely to the rainy season, i. e., the spring and early

summer. While this is particularly true of the land species, it applies also to water forms. The pond inhabiting animals in spring are given more extensive territory, thus increasing the food supply and furnishing better opportunity for the development of the young. The rushing waters of the rivers, except in shallow and swampy areas along shore, are almost destitute of shells. In the western part but one bivalve is found in the



FIG. 22. *Lymnaea palustris*, the commonest fresh water shell.

sand bars of the rivers, the common black clam, *Margaritana margaritifera* L. In the eastern part, tributary to the Atlantic, two Unionidae are recorded, *Anodonta plana* L., and *Anodonta ovata* L. In each case only the young were taken. Three other small bivalves, to be found among the vegetation of ponds, have been collected, one from the western and two from the eastern part of the state. It is thus seen that the total list

of bivalves inhabiting the waters of the state at present numbers but five species.

In most sections of the state rains are more or less constant in the state from early spring until the last of June. In May, June and sometimes early July, land forms may be hunted successfully. After this it is rare to find living animals except in very limited areas around lakes, ponds, or water courses. It is not uncommon to find bleached shells lying out in open and exposed places, but they are usually of one species, *Pyramidula strigosa* Gld., or some of its numerous subspecies or varieties.

To secure shells for the sanilery for class use is not exceedingly difficult, although they are not to be picked up at random. The water inhabiting species may be sought in shallow ponds, among the decaying or living vegetation. To secure them requires a pair of rubber boots, if one does not wish to have wet feet, and some form of a net for dipping them out of the water. The species in greatest abundance which is most likely to be taken is a small gastropod, with tapering spire, *Limnaea palustris* Muell. (Fig. 22). It is found throughout the state, may usually be had in abundance, and is not difficult to keep in the school room or laboratory. With it is likely to be had the smaller and more delicate *Physa*, with left handed turns in the shell. With these specimens in a vessel of water with suitable food a fund of information relative to their habits, movements and life may be secured. They will prove easy subjects for genuine work in nature study, and a large number of persons may carry on original observations. Other smaller species may be had possibly by sifting fine sand and separating the few shells to be had. I have kept many of these minute animals in vessels for months, and they have multiplied and done well. Those I have had were the diminutive *Pyramidula striatella* Anth., *Physa ampullacea* Gld., and *Limnaea palustris* Muell.

The land species must be sought in damp places. My most successful hunts have been in June on rainy days, although they may be had earlier than this. It is usually necessary to search among the weeds and underbrush of the timber along the water courses or ponds, or in the damp canyons and gulches on the mountain sides. I distinctly remember several days in the Mission mountains where specimens were gathered. It necessitated crawling around on hands and knees among rank and dense vegetation, while rain was falling in torrents. While this was very disagreeable, it was the time when snails were active. Even when abundant they are difficult to find, owing to their color. They very much resemble the leaves and dead wood over which they crawl in search of food.

The snailery must be kept neat and clean, for snails are dainty creatures, and will not thrive in dirty cages. The water species will need occasional fresh water. The water of Montana's lakes and streams is so free from mud and silt, as a general rule, and so full of oxygen, that changes need not be made often. Once in two or three weeks will probably suffice if the vessel be large enough to hold a gallon or more. Water vegetation should be supplied, which will not only furnish food for the



FIG. 23. A series of shells showing the varieties of *Pyramidula strigosa* due to high altitude. The largest, to the left, from McDonald Lake, altitude 3,300 feet. The next size, from Tobacco Root Mountains, east of the main range. The third, from the Bitter Root Mountains, altitude 5,000 feet. The smallest, from McDonald Peak, altitude 8,000 feet. Photo by M. J. E.

animals, but will also by its growth supply oxygen for their needs. I discover that pond scum may be kept growing all winter if placed in a south or west window for sunlight. Of course, water species may be kept in winter, when it will probably be found impossible to keep land species. In spring and summer the land snails may be kept in a suitable cage, and with a small amount of care and trouble in supplying food and in keeping the cage clean they will amply repay for the trouble. Pupils will find them interesting, and with a few suggestions will be able to make many valuable observations, and thus get true nature study lessons, a study of the living specimen whose habits and natural peculiarities may be known first hand.

The land snail most abundant in the state is *Pyramidula strigosa* Gld. It is found abundantly west of the Rocky mountains at all altitudes from the lowest elevations to 9,000 feet. The shells found may easily be referred to several varieties. Figure 23 shows their general appearance. The shell is rather thick and heavy, recognized by two dark bands, one of which extends into the spire for several whorls. Closely related to it, and often associated with it, is *Pyramidula solitaria* Say, but the latter is more earthy, with darker color, a trifle flatter, and with broader bands, not extending into the spire. *Solitaria* is less common, and is not yet reported from east of the range.

Pyramidula strigosa has been taken by us abundantly in the western part of the state. It has been found on the slopes of many mountain ranges in the state. It has been taken as far east as Lewistown. It is a Rocky mountain species, and is so variable that conchologists despair of bringing the numerous subspecies and varieties into systematic relations which will be satisfactory. At two places in the Mission range, Sinyaleamin and McDonald mountains, it has been found at high altitudes, as explained in "A Biological Reconnaissance in the Vicinity of Flathead Lake." The lower snails are large and fine looking. The higher ones are very small, greatly reduced in size, and have very hard conditions to fight against in the struggle for a living. While the species is apparently of western origin, its presence at Lewistown shows that it has crossed the range, and is slowly making its way eastward. This is the second species, according to our studies, that has crossed the main Rockies, the other being a dragonfly. As there are seven species found in the state on both sides of the main range it is apparent that they have crossed the range in some way. As *P. strigosa* has been found at elevations up to 9,000 feet it seems reasonable to suppose that it was not carried over by some larger bird or animal, but crossed over by its own wanderings.

Several hundred duplicates have been collected, and two or three will be sent to any teacher of nature study, so long as they last, if postage accompanies the request for them.

It is needless, in this lecture, to attempt giving a list of the sixty species found in the state, twenty-five of which have been found west of the range, with forty-two from the east side. A list may be found in Bulletin University of Montana, Biological Series No. 3, pp. 170-174. Teachers who wish shells identified may send them to the writer, who will

name them without charge. For much work in nature study a name is unnecessary, but it is very desirable. There are no keys available for identification of western species.

It will be seen from the above that the molluscan fauna of the west end of the state is entirely different from that of the east end, but seven being found on both sides of the mountains. As very few collections have been made it is very desirable that material be secured from various sections, and correspondence is invited on the subject and specimens very much desired. If teachers will suggest to pupils the desirability of gathering a few specimens the boys will probably bring them if they are in the neighborhood.

If the animals die, or if it is desired that they be killed so the shells may be used, the process of cleaning the shells and removing the dead animals is very simple. The shells containing the animals are dropped in hot water, and left for a few minutes. This quickly kills the animals and loosens them from the shell. The soft parts may then be removed by a bent pin or a piece of small wire bent at an angle at the end. Perfect specimen may then be made by washing out the inside with a pipette or small syringe. By gently rubbing the outside with a tooth or nail brush and water the outside may be shown off to best advantage. Such shells will ornament any school room or cabinet of collections.

Some of the suggestive points to which attention should be called may now be given.

Habitat. This includes the natural home, whether in water or on land, in the open or among dense vegetation. If among rocks the nature of the rocks should be determined. Shells found in water will suggest running water, sand banks, rocky bottom, shallow ponds, lake swamps, cold springs, or some other varying condition. Every phase of the environment should be noted, and suggestions thrown out for the purpose of having the pupils secure the information individually.

Movements. These may easily be watched, if specimens are kept in the snailery. It is very essential that the conditions in which the snail is placed should be as lifelike as possible, so as to be able to study movements that are natural and not forced. The animal may be watched while crawling around over the vegetation or along the sides of the aquarium. The use of the tenacles, the protrusion of the body from the shell, the withdrawal into the shell in times of danger, the action of the creeping foot during progression, and the movements of the mouth in feeding, all should be noted if possible.

Color and markings. Dead and bleached shells are not of much value, but are better than none. From them few conclusions may be drawn except as to size and shape. Teachers who understand the theory of protective resemblance will find shells suggestive of many things to which reference may be made. Those who do not understand it should make haste to consult some good zoology and discover its meaning. Shells generally resemble the surroundings so closely that they must be sought closely. I have frequently tried the experiment of searching a given spot carefully, to be followed by a second person who will see how many I have missed. A new spot is chosen and the order is reversed. Rarely

will the second person fail to find some overlooked specimens, so closely do they harmonize with their surroundings. This blending of colors applies with almost equal force to the species living in water. Markings may refer to spots or bands on the shell, or to the indentations on the surface. This latter may be coarse or fine, deep or shallow, numerous or few. It may be possible to count the number per inch or millimeter, and thus determine points of variation.

The Spiral. This may be right or left handed, dextrose or levulose. Most shells are dextrose. If shells are in quantity each should be examined carefully to see if perchance an accidental specimen may be found the reverse of the ordinary. Such cases occur. Some species have the shells left handed, turning opposite to the hands of a watch. Each should be examined. The number of turns in the spiral should be counted. A means should be devised for determining the fractional turn at the last, as it is very likely to result in a fraction. By making count of a series variations will be found and a mean established.

Diameter and Depth. Adult specimens should be used. Three straight edges are necessary, one of which should be a finely graduated ruler. Place the shell against the ruler, and put the two remaining straight edges on either side, also against the ruler. The reading may be taken from the ruler directly. With a ruler and two square blocks any number of shells may be quickly measured. By turning the specimen measurements may be made in different ways, and variations noted. It is understood that the value of such work to the pupil depends largely on whether it is done **for** him or **by** him.

Variations. In a mountainous region shells of a given species from different localities or altitudes will show many variations. In fact, not two shells from any place are exactly alike. By noting the above points many lines of variation may be noted. It is possible to determine the direction toward which the species is tending; i. e., it is becoming thicker shelled, with deeper markings, broader bands, fewer turns to the spire, less width and depth, smaller in body, or the reverse. All such observations afford food for reflection, and are excellent mental stimuli. As this is the main thing sought in nature study work the observations should be encouraged by each individual, and not by the class as a whole.

Food. Few suggestions need be given on this. In the snailery different things must be tried. Daily observations may show whether land forms eat living or dead leaves, decaying wood, wet or dry leaves; whether water snails eat living plants or decaying material in the water, or living animals. All observations should be carefully recorded, and at stated times notes may be compared.

Enemies and Unfavorable Conditions. Drouth kills most land snails. Those living in water have no doubt many enemies about which little can be determined. Permit some shells to become quite dry and watch their actions. Notice the film across the shell to prevent evaporation. Other enemies to land snails are rodents, including mice and squirrels. If broken shells are found, examine carefully to see if the break is by accident **after** death, as by washing among rocks, or by an enemy **before** death. This must be determined by the position and character of the

opening, as also by its recurring in a given manner. Observe whether the break is haphazard or shows evidence of careful selection as to place.

Geographical Distribution. Having found the name of the specimen in the snailery, it may be possible to find how extensively it is distributed over the state, over the United States, or over the world. This information may be had by consulting a library with conchological literature, or by inquiry of friends versed in knowledge of shells. In any event, whether the information is found or not, suggestions may be thrown out as to ways by which the species may be scattered, reasons for dispersal, and barriers which may prevent it.

Some Devices Tending to Insure Cross-Fertilization of Plants.

Maurice Ricker.

The oak has a wind-pollinated flower. In some plants the pollen is carried by water. A large number of the conspicuous flowering plants are pollinated by insects, bees taking the leading part, though moths, butterflies, flies, beetles and bugs do much of the work. Some of the deep throated flowers, as the honey-suckle, are pollinated by the humming bird. Other especially adapted plants are said to be pollinated by snails.

Christian Konrad Sprengel was a pastor in a German parish until he neglected his duties, to the extent that he lost his position. This neglect came about through his love of the study of plants. He then made a precarious living by teaching the languages and mathematics, and continued his investigations, the results of which appeared in 1793 in a volume entitled "Das Entdeckte Geheimnis der Natur." He shows in this

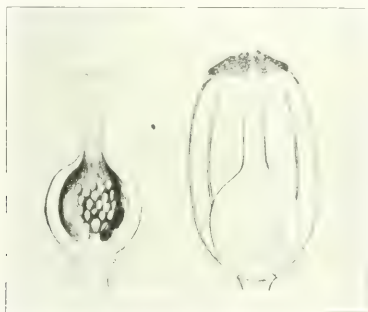


FIG. 24.

book a perfect understanding of the nature of fertilization and believes that insects play a part in putting pollen upon the stigma. Waechter in a memoir in 1801, taught the structure of the orchid pollen-mass, or pollinia, as it is now called, and showed that it must be removed by an insect.

It remained for Darwin to discover the real secret of nature. He approached the subject through experimentation upon flowers fertilized by their own pollen as contrasted with those which are fertilized by the pollen of other flowers. His book on the "Fertilization of Orchids by Insects" appeared in 1862, nearly 70 years after Sprengel's work was first published in Berlin. We have illustrated the difficulties in the way of accepting Sprengel's work and Darwin's final solution of the problem by four charts, after Gibson.

The first (Fig. 24) shows how Sprengel taught the method of fertilization by showing how the pollen is shed upon the stigma by being borne above it.

The second chart (Fig. 25) shows how Sprengel overcame objections to his theory when his attention was called to flowers which bear the anthers below the stigma. It shows bees crawling over the nectaries, incidentally smearing themselves with pollen, and then climbing over the stigma, carrying the pollen with them.

The third chart (Fig. 26) shows the next problem with which Sprengel was confronted. Flowers were found where the pollen is all shed before



FIG. 25.

the stigma is open or receptive to pollen. These are what we now call protogynous flowers. Somewhat similar in nature is the problem of the protogynous flowers where the stigma ripens before the anther. Sprengel is said to have admitted that he could not solve all these enigmas but that, nevertheless, he thought there were reasons for these various structures.

Darwin, coming at the problem from the standpoint of cross-fertilization, saw it as in chart four (Fig. 27), which represents bees going from the ripe anthers of one flower to the receptive stigmas of older flowers; and it was made clear.

In his twelve years of experimentation on the subject of "Self and Cross Fertilization in the Vegetable Kingdom," Darwin showed that not only was it advantageous for flowers to be fertilized by pollen of other flowers of the same species, but that they produced more seeds if fertilized by pollen from distant fields. These two books by Darwin are of great interest to the botanist and may be read with profit by any one. As examples of the experimental method of to-day they are worthy of consideration. I suppose no other man has spent such years of painstaking labor and accompanied his theories with such an enormous amount of data.

Some plants, like the common violet, have two kinds of flowers. We only note the ones that open to insects with their beautifully colored corollas, but there are others, which may be found later in the summer

on the same plant. These do not open but shed the pollen upon the stigma, in the mud, as we might say. These are called cleistogamous flowers and I believe are borne only upon those plants which also produce the ordinary showy flowers, thus insuring cross pollination at some period in their history.

Many flowers provide against self-pollination by some such common



FIG. 26.



FIG. 27.

device as in the bluet (*Houstonia*), where some flowers bear the anthers in the lower part of the cup and the stigma near the top, while in other plants adjoining and perhaps raised from seed from the same plant, the opposite arrangement of anthers and stigmas is found. One can readily see how this will result in preventing self-pollination and furthering cross-pollination.

A still more effective method is found in many flowers where the parts mature at different times, as has been already mentioned. The most effective method, however, is shown in those plants like the willow where only pistillate flowers grow on the one plant and only staminate ones appear on another. These are called dioecious plants. The oak represents the type where the two kinds of flowers are borne separately on the same plant. These are called monoecious plants.

As might be supposed, those flowers which depend upon wind pollination must produce a great abundance of pollen, even though every device such as light feathered pollen be brought into use. The monoecious rag weed and the pines are good examples of plants which shed their pollen freely. We can readily see how great would be the benefit to a plant if an insect could be induced to carry its pollen. The saving in quantity would be considerable, as well as the advantage before mentioned of pollination from a distant plant.

Since there are no one sided bargains in nature the insect must be enticed and paid for his trouble. This involves the necessity of the plant's putting up some kind of a free lunch in the shape of nectar, as in the clover, or edible pollen as in the rose. In the Spiderwort we have some fine hairs growing from the stamens which must make delicious fodder for some of the bees, judging by the way they eat it. Some plants offer lodging for the night and protection from storm and cold. What more could a vagrant insect ask?

The fact that this free lunch is offered must be advertised, either by an odor to entice the hungry insect or by a showy blossom. Some plants with small inconspicuous blossoms, as in the clover, unite into heads so the busy bee can readily go from one to another without loss of his valuable time, for the summer is short.

One can follow out this idea almost indefinitely. Plants blooming at night have white flowers because they can thus be more clearly seen by their nocturnal visitors. They are also more likely to be fragrant. Flowers desiring nocturnal visitors are likely to be closed the rest of the day. Flowers that are open for business only a very short time, as the morning glory, have not only showy flowers but delicate stripes of color running from all sides down to the nectaries, seemingly to direct the insect to the sweets with as little loss of time as possible. These nectary guides, as they are called, are very conspicuous in many insect fertilized flowers. By following these guides, the welcome host will always rub against the essential organs of the flower and thereby assist in pollination, or in other ways pay for his sup of nectar.

It may be interesting here to note that the early botanists thought nectar was a waste product that must be removed, and an early suggested reason for insect visits was to assist the flower in its removal.

While most insect-fertilized flowers are beautifully colored and many of them pleasantly scented there are also some that are flesh-colored. They have a bad odor, as the smell of decaying meat. The visits of carrion flies suggest the purpose of the bad odor.

Sir John Lubbock made an interesting series of experiments from which he deduced the facts that dull yellow, brownish or purple flowers seem to attract flies more especially. Also that bees and butterflies are more likely to go to violet, red or blue flowers. Packard believes that no insect can distinguish clearly color or objects at a greater distance than six feet. What extremely short sighted animals they are! We know that odors will attract flies from much greater distance.

The insects, as well as the flowers, are modified to meet the conditions that arise from this inter-dependence. When Darwin's book was under

discussion soon after its first appearance, some one brought a flower from Madagascar which had a nectary measuring seventeen inches. Some were inclined to ridicule Darwin's theory and ask him to produce the insect having a tongue long enough to reach the sweets at the bottom. Though no such an insect was known, Darwin readily accepted the challenge and declared that he would stake his theory on the proposition that somewhere there was an animal capable of reaching it, else there would have been no such development. His critics were much disconcerted soon afterwards by the finding of just such a moth as Darwin had said there must be.

Let us consider some of the devices for preventing waste of pollen in insect fertilized flowers. We can readily see that after a plant has specialized to such an extent as to secure transfer of its pollen by certain flying insects only, that it may be necessary to arrange some means to keep out a large class of crawling insects, like the ants, which might seek to take advantage of the food and at the same time be of no use to the flower. They would not be adapted to transfer pollen to another plant in good order. The nasturtium for instance has numerous bristling hairs that bar the way to the nectary. The snow-berry has a perfect ball of cotton over its sweets. Some plants as the sunflower have such spiny, hairy stems as to discourage creeping visitors. Other plants secrete sticky gums which act very much in the same way as hairs, in that they are a serious impediment to insect travel. Some plants, like the milkweed, have smooth, waxy stems which are easily punctured by the sharp claws of a climbing insect. When the plant is injured the sticky milk will flow out and one can readily understand how disgusted an ant would soon become with such a plant. The rubber plant has sticky sap for the similar purpose of self protection.

Numerous schemes for prevention of visits by any other than the favored guest might be cited. The nectary is often located in long spurs where only long tongued insects can reach it. The columbine has five such spurs. The common flies and bees cannot disturb this flower. It reserves its nectar for certain long tongued insects. The bumble bee sometimes thwarts nature's scheme by alighting on the outside of the flower, and cutting a hole for a back door, as it were, drains the nectaries dry without having touched the essential parts of the flower. If this ingenious device of the bumble bee should become universal among bees it might have a serious effect upon the plant's survival. It would then have to depend upon allies of the butterfly order, who carry no knives, to make the first call.

One of the most astonishing tricks in the plant world is played by the blue flag or iris. One must examine a flower and find the parts to fully appreciate the situation (Fig. 29.) At last you will find the false honey guides running down the interior of the flower and Needham reports that many insects seem to make the very natural mistake of probing down the center of the flower as indicated by the guides, for the nectar. They find nothing and go away no doubt with a poor opinion of the flag.

A bumble bee, for whom the flower seems especially designed, alights



FIG. 28.

*FIG. 29. The blue flag. From water color drawing by Mrs. Edith Ricker.*

upon one of the graceful sepals and his weight is just sufficient to separate it from the closely covering carpel. The bumble bee then wedges himself in between the slowly opening part and, by stretching his long tongue to its full length draws the nectar from its deep well. The true honey guides are on the upper surface of the petal. The cover is a style and bears the stigma on a shelf like projection just where the bee will rub his head and thorax in wedging himself in. The stamen rises and bears an anther at the point where it will rub the pollen into the thoracic hairs of the bee. Why is not this same pollen left on the stigma when the bee backs out? If the stigma shelf is rubbed with the finger it opens



FIG. 30.

outward as by a bee in entering, and closes when rubbed the opposite way. Thus the pollen gathered from this flower will be transferred to some other flower. The blue flag teaches us several lessons in adaptation. All of the irregular flowers are peculiarly shaped with reference to their insect visitors. They are a source of never ending speculation.

Protective closure to keep out rain and unwelcome insects has been mentioned earlier. The hanging position of many flowers serves the same purpose. Many flowers have a movement of parts in addition to this closing, some of which are of great interest. My attention was first called to a closing of the lips of the stigma in the catalpa. Near the station, at Big Fork, is a swampy place where many interesting plants

abound. On inspecting a number of blossoms of *Mimulus* (Sp—) (Fig. 28) I found the styles different in various plants of all ages and proceeded to tickle them with a straw. The style divides into two flat surfaces at the end which spread widely apart, as is so often the case. Selecting one that was well open. I found on touching it that it closed slowly and in perhaps thirty seconds was shut up as tightly as if it had never been opened. After a few minutes I visited the plant again and found it was slowly opening. The plants taken to the laboratory for experiment did not stand the trip very well, and reacted somewhat more slowly than in the field. When fertilized with fresh pollen from another flower the style will remain permanently closed.

We now come to one of the most interesting arrangements in the botanical world illustrating plant movement to bring about cross pollination. The sage was figured in Darwin's earliest work of this kind and given to the world as a wonderful piece of floral mechanism.

The sage flower is irregular, having one of the petals produced into a landing place for flying insects (Fig. 30.) The anthers are modified with a peculiar arrangement which can be better understood from the figure or the section of the flower. Two standards carry each a sort of C shaped piece, which is delicately poised so as to stand in a nearly vertical position, if the flower is held horizontally. A bee in order to enter the flower must go between these standards and in so doing will necessarily push the lower part with his head and rock the anther bearing part over so as to dust his back with the powdery pollen. Since the sage is proterandrous, the stigma will be non-receptive even if it were far enough out to receive the pollen. If the next sage visited has a ripened stigma the style bearing it will have grown long enough and will curve down so that it must rub the back which was lately dusted with pollen. The bee will receive no pollen from such a blossom as its pollen has all been scattered. The sage has indeed a wonderful story to tell to those who will stop to consider it.

Certain flowers greet the entering insect with a bombardment of pollen. This is produced in various ways and does not seem to be anything of a surprise to the visitor who proceeds to collect his fee for carrying his load of pollen to the next flower.

Our common Milkweeds have a waxy pollen mass and will need investigation. They have been charged with the murder of hundreds of innocent guests and any summer day one may find them holding their dead victims fast by the legs. The insect finds himself caught and is perhaps, unable to pull his legs out of the trap or pull the trap with him. This trap, which consists of two bags of pollen, he is supposed to take with him. An insect's foot, coming into contact with the V shaped slit in the trap formed by the union of the two pollen bags, is quite likely to be caught. If the pollen be ripe, and normal in every way, any ordinarily strong insect is able to pull the pollen sacks free from the flower if he does not get too many feet caught at the same time. If he has a foot firmly fastened in one flower and in trying to pull out tangles another foot or two, he may tire himself out and die after a hard struggle. Insects usually succeed in pulling out the pollen sacks. These they carry to another flower, and drag over the stigma with the desired effect.

The orchid represents the most highly specialized flower and a consideration of these wonderful forms must be left until another time.

The Plant Associations.

Harry Nichols Whitford.

From what has been said in the preceding pages it can readily be seen that the climate affects the distribution of plants. The so-called **plant formations** are the direct result of certain climates. However, the landscape of a **forest formation** (Fig. 5) does not show an equal distribution of the kinds of trees in it; nor does it show an unbroken mass of trees. On the other hand there is a tendency for trees of certain kinds to be growing together, and there are gaps in the forest, island-like openings, as it were, in the sea of trees. The gaps may contain a meadow, a heath, or even a prairie. A **prairie formation** may also contain trees in certain favorable situations (Fig. 5) where there is a sufficient water supply. In distinction from the **formation** these groups have been called **plant associations** or **plant societies**. It is now in order to inquire what causes have brought about the division of **formation** into **associations**. This can be done best by selecting a limited region in the forest formation, for example, and by noting what associations are found and in what conditions they are growing. The region around the Montana Biological Station at Big Fork is a good one to illustrate the point. Any region in the state can be studied in the same way, whether it be in the prairie or forest.

In the **forest formation** near Big Fork there are five more or less distinct **plant associations**. In the low places in the Swan river valley along streams and around ponds are moist areas that are usually submerged during the spring and early summer months. These are known as **meadow associations** (Plate LII.) The grass type prevails in these places, grasses and sedges of various sorts being here associated. Oftentimes peat moss is abundant, and with it may be found the interesting carnivorous plant called sundew. Around the borders of the meadows, and sometimes in them, are willows, alders and birches. Shallow ponds containing water lilies and pond weeds are often found in the meadows. It is very evident that the reason why trees do not grow in these meadows is because there is too much water, which, like too little water, is injurious to them.

Bordering on the meadows are localities, not quite so damp, where the Engelmann spruce and other plants growing with it are found, forming what may be called the **Engelmann spruce association**. On the edge of the meadow the trees of this association are small and scattered. Depending on the amount of water in the soil, there may be peninsulas and islands of spruce in the meadow. Sometimes there are almost pure stands of spruce forests; again the spruce element is scattered along streams. Very often lodgepole pine, narrow-leaved cottonwood, aspen, and birch are associated with the spruce. These particular combinations of trees are always found in soil that is quite damp, but not so damp as

the soils in which the meadows occur. It must not be supposed from what has been said that the trees mentioned above never grow in other situations, for they do, as will be seen later. In the spruce associations they are the predominant trees. In some of the other situations, they are subordinate.

Around the drier borders of the spruce association, and sometimes on peninsulas or islands in it, are stands of trees other than those mentioned. These trees are clearly associated with soil in which the water level is still further beneath the surface. Because the western larch and the Douglas spruce are the most common trees in this stand, it will be given the name of **western larch—Douglas spruce association**. Far the greater part of Swan valley is occupied by this association. Other trees in it are the lodgepole pine, lowland fir, silver pine, and occasionally an arbor-vitae. The Engelmann spruce and the birch are sometimes present also, though they seldom form a conspicuous element. The lodgepole pine (Plate LII) occupies vast tracts of this area. Its presence here is clearly due to fires. Often the older trees of western larch and Douglas spruce, their charred trunks telling the story of former fires, are seen standing above young forests of lodgepole pine. Sometimes almost consumed trunks show that the fires have been more destructive. The western larch and the Douglas spruce are the last to be killed by fires, because they can resist them best. Where fires have not been so destructive, the lodgepole pine is less conspicuous. Indeed, in places it is almost entirely wanting. The lowland fir, silver pine, and Engelmann spruce are more abundant in the moister parts of the western larch-Douglas spruce association. In isolated patches the bull pine is also found.

Just as the meadows form treeless places in the forest formation so occasionally the soil may be too dry to form forests. It is a well known fact that clay soil holds water better than sandy soil. The rainfall may be sufficient to support trees in the former, where it would not do so in the latter. This fact may account for the prairie "islands" in the **forest formation**, to be seen in Fig. 5.

Surrounding these prairie islands and bordering on the **prairie formation** is another type of forests which is due primarily to the fact that there is more water in the soil than in the prairie, and less than in the western larch-Douglas spruce association. This type of forest may be called the **bull pine-Douglas spruce association**, because these two trees are the predominating ones. Sometimes the western larch is found with these, but it never occupies the drier soils. In other places the Rocky mountain juniper is present. The bull pine-Douglas spruce forest usually is an open one, with grass patches between the trees. It grades imperceptibly into the prairie formation.

In the foregoing it is shown that the type of plant associations in the forest formation depends on the amount of water in the soil. Warming, a Danish botanist, who was the first to fully perceive this relation between the grouping of plants and the amount of water in the soil, classified plants into **hydrophytes**, **mesophytes**, and **xerophytes**. Those plants that grow in soils with a great amount of water in it are known as **hydro-**

phytes. This word comes from *hydor*, meaning water, and *phyton*, meaning plant. Those plants growing in soils with an intermediate amount of water are known as **mesophytes**, that is, literally intermediate plants. Those plants growing in soils that have little water, are known as **xerophytes**, that is, dry plants. Now it is convenient to use the terms **xeromesophytes** and **hydromesophytes**. So under this classification the associations discussed above are as follows:

A wet meadow is a hydrophytic association.

An Engelmann spruce forest is a hydromesophytic association.

A Western larch-Douglas spruce forest is a mesophyte association.

A Bull pine-Douglas spruce forest is a xeromesophytic association.

A prairie is a xerophytic association.

In the **prairie formation** there are two places where trees may grow, namely, along streams and on protected hill sides. It is obvious that in the former situations the roots of the trees penetrate to or near to the underground water level, which is not far from the surface. In the latter situation (Plate LII) the fact that trees are protected from drying winds and the soil from the heat of the sun, prevents both trees and soil from drying out rapidly. The plants that grow there can get more water and give off less than they would absorb and transpire if the hill were not present. Thus the protected slope of a hill may have forests in a **prairie formation**.

Again, if a hill be high enough to cool sufficiently the moisture-bearing winds so as to cause precipitation of moisture, it may get more rainfall than the lower lying land. This is very probably the reason why the tops of mountains or of high hills in prairie regions have trees and sometimes dense forests. This leads to the discussion of the forest conditions in high mountains.

The climate towards the top of a mountain is different from that at its base. It is always colder and usually more moist. The moisture conditions are favorable to trees, the low temperature conditions are against tree growth. The slopes exposed to dry winds have less moisture for trees than those not so exposed. At the same time the exposed slopes receive more heat, rapidly melting the snow, which would otherwise lie longer, and thus shorten the season. As a consequence tree growth is more prevalent on these slopes than on the protected slopes where the snow lies the year round. As one ascends a mountain like MacDougal's peak or Hall's peak, which are in the Swan range bordering the Flathead valley on the east, the species that require the most heat will disappear first. Those that are adapted to a shorter season will be found higher up. The bull pine is one of the first to disappear. Higher up the western larch and silver pine are absent, and on the ridges the Douglas spruce and lodgepole pine are the last of the lowland forms to disappear. In the valleys the Engelmann spruce will be found as high as these or higher. Before the conditions are too severe for the last three named species, the alpine trees come in. In the region under discussion these are the white-bark pine and the alpine fir. (Plate XLVII.) It has already been shown that the latter species is found occasionally in the valley. In the cold canyons it and the Engelmann spruce may

form almost pure forests. Near the top of the two mountains under discussion, the exposed places have only the two alpine trees, the white-bark pine and the alpine fir. In basins on the east side, however, the conditions are different. Here the snow lies longer. The white-bark pine is infrequent here, but the alpine fir does better than on the exposed ridges. In the basins there are three distinct plant associations. On the steep slopes where the weathering processes are frequently adding new rock material, (Plate XLVII) the conditions are too strenuous for the existence of any plants. As soon as one of these talus slopes becomes stable enough, then plants begin to get a foothold, and finally trees may



Fig 31. Portion of an alpine meadow, 7000 ft. altitude, Swan range, August, 1903. Photo. by M. J. E.

appear. In places where the snow lies the year around, there is no vegetable life except the simple one-celled plant known as the "red snow." Bordering on these snow banks are the so-called alpine meadows. (Fig. 31.) They usually follow up the retreating snow and sometimes dog tooth violets, spring beauties, and anemones come up through the snow itself. Thus one can see these forms just appearing on the border of the snow field. At a little distance they are in full bloom, further away where the snow has disappeared earlier they have produced seeds, and still further from the snow they have finished their growth and have died down to the ground. It is usually in the latter places that one finds groups of trees, (Plate XLVII) nearly all alpine fir, for they appear where the snow first melts. Thus there is a relation between the plant societies found in these regions, and the time snow lies on the ground.

General view of Rost Lake from the outlet. The Swan Range of the Kootenais is in the distance. Around the lake are tree or forest plant association. Bordering these are meadow societies. In the water are hydrophytic forms.



Bird Music in the Flathead Region.

Perley Milton Silloway.

Bird music is the blossom or flower of bird life. The plant is with us throughout the summer and perhaps throughout the year, but its fragrant flower attracts our attention during only a limited period of its summer life. So it is with the bird song; it reveals a life that may have been neglected until that time, and for a brief period we wait and listen for the bird. A little later the song dies away, and the author is likely to be overlooked during its further existence among us.

The bird song is an index of a changing phase of the bird's activities. Its humdrum habits of the workday world are to be laid aside for a time, and it is to enter upon a brighter and more joyous period of its yearly round. New impulses actuate its little breast, and its kindling spirit leaps forth in song. For weeks and months it has been silent, except in such calls and cries as have been impelled by its usual emotions, but as it sees its little world enlarging to renewed companionship and more enjoyable relationships, it gives unusual utterance to impulses newly aroused, and the song becomes a part of its daily experience.

As is well-known, the gift of song is generally confined to the male bird. Though the rule is not invariable, the exceptions are few enough to prove the rule. The fact that the male bird alone produces the real song has led to the conclusion that the song is a means by which the male announces his presence to his lady-love, and by which he seeks to attract her attention to his graces and accomplishments. Bird music is the forerunner and accompaniment of the mating season, and continues through what may correspond to the "honeymoon" of more rational beings. The song is prompted by the sexual instinct, and in the mating season is doubtless designed to please some listening female. Once her attention is attracted and her ear captivated, the song becomes one of the ways in which she is wooed and won. After she has been won, the song becomes an index of the domestic bliss of the songster. With many birds, the season of song ends quite abruptly with the beginning of the female's household duties; with a few, the period of song is prolonged even until the younglings have left the nest and are able to forage for themselves. In some instances, there is what appears to be a fall period of song, though the fall singing of any bird seldom equals its vernal performances in power and volume.

Some of the birds come to us on their way northward in the spring, caroling in the renewal of their domestic felicity. During the weeks of winter we have missed the presence of the songsters, but on some auspicious morning we hear the old familiar carol, and we note that one of our avian friends of last summer has returned to us. So our bluebird comes to us, and sitting in the top of a convenient tree or on the ridge of some low building, it warbles its tender message of the returning spring. For several weeks after the advent of the bluebird, the low-

voiced utterances of this species charm our ears. Then the songs cease in frequency and spirit, even before the sitting bird has seen her younglings break the delicate blue-tinged shells. When we arrive at the Biological Station for our annual summer outing, the voice of the bluebird has been hushed, so far as its song is concerned; its tender calls, however, can be heard as we chance on the birds flitting from the deadened boles of the adjacent ridges. To some of us, at least, these calls are a plaintive reminder of the earlier song season, and are worthy of a place in our thoughts regarding the bird music of the region.

Of our familiar western robin, what shall we say that has not often been said? In his usual business-like way, he comes from his southern sojourn, squeaks about the neighborhood for a day or two until he gets his bearings and ascertains that everything is as it was when he departed late in the preceding autumn. Then he begins his recitals, generally from the topmost branch of the tallest tree in view, giving his lyric as a fitting ending to a day that has begotten in us a genuine case of "spring fever." There are but few feet in a verse of robin music, and that verse is oft repeated. Florence Merriam has quite accurately described the song in syllables "trill-er-ee, trill-er-ah." Generally the song is enunciated in a loud, hurried manner, so nervously that it appears as if the songster were losing breath; at times, however, the song is uttered in a high, squeaky falsetto tone, the same performer sometimes changing from one tone to another at will. Again, the singing is done in a low, subdued tone, for our friend robin frequently drops into a poetic mood, especially if his fair charmer is sitting near, and often whispers his flat-teries into the ears of his promised bride. The song season of the robin is longer than that of the bluebird, and in this region is prolonged by some individuals well into July, the late songs, however, being heard chiefly early in the morning and less frequently late in the day.

As we skirt the shores of Daphnia Pond (See Plate XLIX) in quest of biological specimens, the singing of the catbird greets us like the strains of familiar music. Nowhere in this region is this gifted songster more numerous than on the enchanted shores of Daphnia Pond. In the bushes there the catbird nests until late in August, and as it thus prolongs its domestic duties, it carries the spirit of song far beyond the season common to most of our bird musicians. Sitting in some secluded nook of the bushes, this songster gives expression to its impulses in voice low and sweet, in most fitting accord to the fast ebbing tide of summer bird music. The opening hours of the day are generally used by the catbird in its recitals of the later season. At such times we must rise early in the morning if we want to hear the birds begin to sing. In the cool morning hour the catbird is at its best, and if a nest is anywhere in the neighborhood, the listener is certain to be regaled by a prodigality of wild-wood music by the gifted owner of the household.

The warblers, notwithstanding their name as a group, do not excel generally in musical powers. Many of them, though, are songsters of no mean ability. The vocal power of the warblers that occur in the Flat-head region serve about the same function in the woodland chorus as the side horns in the instrumentation of a large band. They are not soloists

nor leaders, but they furnish the harmony in accord and accompaniment, and thus aid in bringing about an effect which is quite satisfying to the listener. So it is with the efforts of that gem of the swamp-woods, the American redstart. Its song is short, ringing verse, very similar to that of the yellow warbler, and is repeated from time to time with great energy and earnestness. Like the catbird, the redstart nests comparatively late, and hence its singing is an incident of our life at the Station during these summer sessions, in the early part of July.

Any of us who has been so fortunate (or unfortunate) as to have been delayed at Selish, may have heard the peculiar notes of the long-tailed chat in the bushy tract near the depot. The chat itself is one of our beauties, a yellow songster somewhat smaller than the catbird. No other bird, unless it is one of the smaller sparrows, understands so well and practices so much the art of skulking. When you are looking for the chat it is certain to be behind a convenient tangle of branches or foliage. Its music, though, will continually come to your ears, not in song, but in a series of strange whistles, suggestive of schoolboy signals, and uttered in varying intonation. It is to be hoped that the chat will work its way northward and establish itself among the bushes of our classic Daphnia.

(In 1903 the chat appeared in the bushes of Daphnia and its song was heard daily.)

Another warbler whose song can not be overlooked is the western yellow-throat. This handsome songster skulks in the reedy tangles of Daphnia Pond, and there its energetic singing regales us who have an ear open to the voices of the birds. The song of the yellow-throat is an accompaniment of the July afternoons, for this warbler has a note till the end of the nesting season. The usual production may be represented by the syllables "wich-i-ty, wich-i-ty, wich-i-ty," generally in series of three, with the emphasis on the leading syllable. It is a loud, ringing song, uttered with persistence throughout all hours of the day, and always from some low situation. The songster is a handsome little yellow creature, easily identified by the band of black which marks his upper face and forehead. His less musical spouse lacks the black markings, and is not so readily distinguished from other small yellow birds, but she may be known by the rich yellow of her throat on the under side.

The two representatives of the vireos fill no mean place in the avian chorus of this region. Both are persistent songsters, and through all the summer their voices can be heard mingling with other wildwood performers. The warbling vireo utters a series of hurried, subdued measures, characterized by a plaintive intonation, forming a most pleasing song in gentle accord with its surroundings. The song of the red-eyed vireo is a loud, monitorial repetition of three or four syllables, easily identified by its peculiar delivery. This songster has been called the "preacher" because of its monitorial style of execution in its singing. Wilson Flagg has aptly translated the song of the "preacher" in these words: "You see it—you know it—do you hear me,—do you believe it?"

The vireos are unlike most of the birds in the manner of their singing, as they prefer the shade of the foliage of the deciduous trees they

haunt, and do not choose a perch out in the bright sunshine from which to render their measure. Again, they do not sit and sing simply for the sake of singing, like many of our songsters; their singing is incidental, uttered as they appear to be busy in gleaning their daily bread from the foliage of the trees. The female of the warbling vireo is equally gifted with song-powers with her mate, and she has a pretty habit of singing in response to her spouse while she is sitting on her nest.

In respect to song, the cedar waxwing is one of the most peculiar birds we have, for it has no real song. The only utterance of which the waxwing is capable is a soft lisping call. Even in the mating and nesting time the waxwing can voice its emotions only in these feeble lisplings, which are scarcely forcible enough to be described by our idea of the word chirp.

A voice of considerable importance in the bird music of this region is that of the Louisiana tanager. This songster frequents the coniferous trees of larger size, where its bright yellow attire, ornamented with black wings and crimson head, seems in strange contrast to the dark evergreen of its environment. The song of the tanager is much like that of the robin, so much like it in fact that the listener must discriminate very closely to distinguish the difference. The tanager's singing is more nervous, and more sharply uttered, lacking the full treble of the robin's performance. This splendid gem of the coniferous woodlands is not sparing of its music, and continues in song well into July. Its frequent recitals serve to apprise us of its presence near the Station; even from the Station door we may hear its characteristic song from the tall conifers that line the river's bank.

Another songster of late summer is the lazuli bunting. It frequents the roadsides, singing a-perch of telephone wire or in the top of some tall tree. Its song is a pleasing little ditty, uttered with great persistency and considerable spirit, though with little variation. The performer may be known by his coat of indigo blue, his orange-tinted breast, and light underparts. He is a little fellow, scarcely larger than our chipping sparrow. His continued ditty is probably prompted by a cozy cot of dried grass in the bushes below or in the near neighborhood, in which his more demurely attired spouse is nestling her pale light-blue eggs.

The black-headed grosbeak contributes a generous share toward the bird music of this region. This songster has a rich, full voice, and its song is somewhat like that of the robin or that of the oriole, what might result by a medley of the songs of the two lyrists mentioned. The grosbeak frequents the deciduous trees, preferably the dwarf trees in low situations, in company with the vireos, redstart, and cedar waxwing. It is also a songster of late spring and early summer, and consequently we hear its mellow music in the early part of July. Like some others we have mentioned, the black-headed grosbeak is well at home on the shores of Daphnia pond, where it rears its brood in the low trees. The male is a model husband, for he is noted for his care of the household. He it is who sits at home brooding the eggs, while his spouse visits about the neighborhood with other grosbeak dames. When the youngsters are

ready to leave the parental roof, it is the male who usually takes them in charge and instructs them in the way of making an honest grosbeak living.

Another songster of the bushes is the arctic towhee. It prefers the shrubbery in the neighborhood of ponds and streams and lakes. Its song is not a masterpiece of musical power, but it has a place in the wildwood orchestra, and would certainly be missed by anyone who has learned to know it. The usual call of the towhee is a group of about two syllables, which has suggested its name, for it resembles the word "towhee." The singing of the towhee consists of short series of notes suggesting the words "Ain't I pretty?" repeated with monotonous persistence from some low situation. The ending of the performance is a rattling trill, uttered with rising inflection and slurred in its hurried execution. The song is very easily identified by close attention on the listener's part.

The mountain song sparrow is one of our masters of song. It is a hardy little creature, being among the earliest to arrive from the south in the spring, and one of the first to open the vernal season of song. By the time our Station work begins, the high tide of sparrow music has spent its force, and all that remains for us is the slowly subsiding ebb. Our song sparrow, though, is one of the few songsters that can utter its cheerful roundelay at almost any season. The males are generally in song until they take their departure in the fall, and at any time one of them is likely to give a gentle, tuneful recital.

The song sparrow is famed for its varied repertoire in musical performance. The singing of any particular songster is much the same to ordinary listeners, but with no great degree of discrimination it can be perceived that a number of different songs make up a day's program of this little virtuoso. The same song may be given an indefinite number of times, when the songster will vary the arrangement so strikingly that the result will be a different song, which is repeated at impulse. Thus from time to time each song sparrow shows himself to be a master of eight to ten songs, each so unlike the others that it will pass for a different song. Generally the song begins with several distinct notes of equal value and tone; then there follows a series of hurried, blending syllables, ending with a cadenza of tuneful spirit.

In our account of the bird music of this region, we must not forget our junco, not because of its leadership in song, but because its music is a part of the later springtime which we enjoy in the early days of our Station season. Furthermore, the singing of the junco is so similar to that of the familiar chipping sparrow, that it is worth while to mention it that we may give the former its due share of credit for the rattling trills that we hear so frequently in the woods. The song of the junco is louder and sharper than that of the chipping sparrow, though like that of the latter, it is a series of monotonous chirps. It is usually uttered from one of the taller trees, preferably one apart in the sunshine or in the margin of the woodland.

In most portions of the Flathead region the singing of the western vesper sparrow is a noticeable feature. You remember it is the song of this sparrow about which John Burroughs wrote so charmingly. Someone has described the performance of the vesper sparrow as that of the

song sparrow reversed, for it begins with the candenza, and ends with the two, three, or four accented notes. At the southern end of Flathead lake the western vesper sparrow is prominently abundant, and if it should chance to be your fate, as it once was mine, to spend a Saturday and Sunday at Polson waiting for the steamer, you will have ample opportunity to become acquainted with the musical powers of this gifted songster.

What limit shall we place to our definition of bird music? As we sit in the Station grounds, we hear overhead and about us the sibilant calls of the pine siskins, as they sport from treetop to tree in their social movements. It is music to the ears of the bird lover, at least, if it will not pass muster among the classic performances of the thrushes, tanagers, and grosbeaks. The pine siskin has no song, but its calls fill a large place in the avian chorus hereabout. One of its calls is a plaintiff "pee pee," the same as that uttered by the goldfinch as it swings in its billowy flight in the sunshine of late summer.

When we brave the tangle of the thick arbor-vitae swamps that crowd some portions of the banks of our splashing streams, we may hear the singing of the winter wren. Indeed, we may hear it on the banks of the Swan river, within fifty yards of the south end of the bridge near us. It is a peculiar song, but it is real music, a gush of hurried, spirited semi-demi-quavers, every note of which is emphasized by a movement of the tail of the nervous little performer. On the rocky ridges of the "Big Burn" east of the Station, the western house wren sings its roundelays, with which you are doubtless rather familiar. In the swamps at the head of Swan lake, we have the tule wren, the western representative of the long-billed marsh wren. The singing of the three foregoing species has a decided generic resemblance, but the performance of each is characteristic and worthy of special note in an extended study of Flathead bird music.

There are many voices which enter into the composite product of bird music of this region, that can not have even a passing mention in a paper of this length. One of our most common songsters, the olive-backed thrush, has not been noticed because of our inability to describe its singing in any adequate terms. It is not a fine song, and is in no wise worthy of comparison with that of its eastern relative the wood thrush, but during our sojourn at the Station we hear it in numbers, and should cultivate an ear for it. In the latter summer the evening grosbeak calls with its loud chick-like chirp as it passes among the treetops in its daily activities. Among the evergreens of the rock ledges we can identify the grasshopper-like chirps of the kinglets, and in the lower woods the long-tailed chickadee has an occasional word to say. Nuthatch and creeper visit the Station grounds and announce their presence by their feeble calls. The swallows twitter a-wing near our boarding-house. Our enumeration of the bird-voices must close. Let us remember the words of the Great Teacher "He that hath an ear, let him hear," and though our present application of the saying may somewhat pervert its meaning, let us cultivate the faculty of hearing Nature's voice through the calls and songs of the children of the air.

Plankton Studies and Their Utility.

Maurice Ricker.

This production is intended to give the students at the Station an insight into the work the University is attempting to do on the plant and animal life of the lakes, streams and ponds in this part of the state. Still better would be a few days spent in the field and laboratory with the workers.

I may say in passing that none of the activities of the Station workers appear quite so mysterious to the uninitiated as does the plankton collecting. People expect to find an occasional crank pursuing butterflies with a net. The gathering of bird-skins and even nests and eggs by the enthusiastic collector can be accounted for, because they have seen such things displayed in museums. The same might be said of the work of the botanists, for people have been accustomed to herb-gatherers and their pressed flowers since time began. The geologist, with his interest in all kinds of rocks, is regarded always as a prospector. But what shall they think of the men who labor for hours, often in the darkness of night, and even in storms; rowing a boat for miles over rough seas, or wading dangerous swamps, just to pump water through a little silk net, the contents of which the collector carefully empties into a small bottle. They watch him put in a carefully measured preservative and chuckle over his catch of objects which are all but invisible. Thereafter the term "bug-house people" takes on a new significance.

Could they know the months of labor spent in studying these forms, dissecting out and drawing parts too small to be seen except under the compound microscope; the poring over drawings, and the tedious translation of works in other language; then they surely would be convinced that the student was the victim of no trifling mental aberration.

At a risk of becoming tedious and commonplace, I must begin by recalling a few facts well known to many of you. July 1, 1738, Charles Darwin opened a note-book for the purpose of recording facts bearing on the transmutation of species. Fifteen months later he happened to read, for amusement "Malthus on Population."

In February, 1858, Wallace lay in a chill, and while thinking over the positive checks, disease, war, famine, and so forth; as discussed in the essays of Malthus, he conceived the idea that those who survive these checks to population must be the stronger ones. In two days it was on its way around the world in a letter to Darwin. Darwin had written 240 pages on the same theory some fourteen years previously, but the essay had never been published.

I need not tell you how this doctrine has revolutionized the thought of the century, and what an impetus it gave to the most minute study of every living plant and animal. Every creature became a big interrogation point. The question was no longer, how does it look, so that we may

classify it and place it in its pigeon-hole and give it a long name. The plant or animal became a much more interesting problem. Men began to look beneath the exterior appearances, to speculate as to the cause of its existence, and to trace its relationship with the plants and animals about it. Every plant or animal, however insignificant, became a link in a series of ever branching chains.

Let us recall the story of the man who began to study yeast plants some years ago. He took up that interesting old problem of how life began—whether it arose spontaneously, or whether like begets like. So he worked for years over his glass tubes, with and without stoppers, with long, finely-drawn-out, bent necks, or with no necks at all, their contents variously treated.

Had skeptical friends remonstrated with him for wasting his life over such trifles that taxed the highest powers of his microscope—and no doubt they did—I can fancy his reply, insisting that they go on with their important matters of life. There were balls to be attended, politics to be discussed, goods to be bought and sold, fashions to be studied. Paris is such a busy place. And so they took up the weighty things of life, while Pasteur laid the foundation for the science of bacteriology. This science in twenty years has robbed the rusty nail of its terror, shown the way towards the ultimate solution of the problems of diagnosis and possibly the cure of all diseases caused by micro-organisms. To-day Pasteur's picture hangs in nearly every hospital and physician's office in the world.

We could supply an abundance of illustrations showing how men in following pure science have laid the foundations for future great works. Seldom does a man take such a prominent position as discoverer and yet live to put his investigations to some practical use. Read of the work of Young and Fresnel a hundred years ago, on light. They were unread then. Franklin and the ladies and gentlemen of the French court toyed with electricity a hundred years before it was practically in use. Oersted demonstrated electro-magnetic action, and yet failed to produce a motor. Davy separated metals nearly a hundred years before their practical use. These men builded for the future, and we enjoy the heritage they left us.

There is a three-fold reason for the immediate study of the microscopic life of these waters.

Firstly—There remains much to be worked out relative to the place and importance in nature of these animals and plants; and the knowledge of them is essential in order that the sum of human knowledge regarding the inhabitants of the earth may be complete.

Secondly—These plants and animals have a wonderful economic importance little guessed by the layman. This will be brought out later under the subjects: (1) food for the higher forms, and (2) their work as scavengers.

Thirdly—The work must be done at once, before man shall have cut down the forests, clogged the waters with saw-dust and much worse sewage. In fact before man shall have so changed the face of nature that a scientist seeking for some primitive conditions where life can be studied in its natural balance, would seek in vain.

If I am able to make but one point to-day let it be that this Station

offers the rarest opportunity for this kind of investigation. This region should be studied in such a way that the work done will be valuable reference when compared with changed conditions which are sure to come later.

All water life is divided into two great classes by no hard and fast lines. These are littoral and pelagic. The former has to do with life on or near the shores. The latter deals mostly with the floating life of the waters, and it is included in our plankton studies. The term plankton is applied to the plant and animal life that moves with the currents. Floating algae and such minute swimmers as the microscopic crustacea would be included, while fish and other free swimmers would be excluded. It is an occasion of surprise to some to find that the quantity of such matter in any large body of water is so great that the fixed plants along the shore, and the animals they harbor, are comparatively insignificant in a consideration of the total life.

The number of individuals in a lake like the Flathead is beyond comprehension, and the number of separate species is large. The quantity of life if collected in one mass would weigh thousands of tons.

We know that the total amount varies greatly from season to season, and it will be soon shown that there is reason to believe that there is quite a range of variation in the relative numbers of organism from year to year.

We are learning something of their daily movements in summer. To undertake the studies of quantity and composition requires additional means of transportation, apparatus time, and literature, and an infinite supply of patience. Time and patience can not be purchased in the markets, so the plankton student must bring these with him.

If you care to make the trip go with me in the Missoula and we will push over to Station B. This location will be plain enough to you if you take the bearings. Station B, is at the crossing of two imaginary lines drawn one from the point of the delta to the club house, and one from the rocky point in the bay, down the middle of the bay. (See Plate XLVIII). The other stations are located by a similar method. From soundings we find we have eighty feet of water. The temperature at the surface and at various depths, the time of day, the nature of sky and water are recorded. The Kofaid net of fine bolting silk is then carefully adjusted over the side of the boat, and the pump and hose made ready to use.

Pumpings are now made at the surface by holding the end of the hose from one to three inches from the top. This catch is put into carefully labelled bottles with numbers corresponding to those in a note-book, where the data before mentioned are kept. The plankton is preserved in a one per cent solution of formaldehyde. Other pumpings are made at three, seven, fifteen, twenty-five, fifty feet, and to the bottom, and the collections properly labelled. We then proceed to similar operations at the other stations.

We have endeavored to make daily collections the past two years while the station is open. You can readily see how valuable would

be one year's continuous work, daily if possible, to discover seasonal changes.

Let us now go to the laboratory and examine the collection. We usually tow the net over the surface, and have taken very many bottles of this material. We will examine an average sample from a representative bottle, under the compound microscope. You will be delighted with the beautiful forms, the delicate desmids and diatoms, and those wonderful creatures classed broadly as microscopic crustaceans, and more properly as *entomostraca*. Note the beauty and variety of this life, and then I doubt not you will be seized with a desire to know their names and uncover their secrets. We would soon have you dissecting out the fifth feet and noting other characters, for we must classify whether we like it or not. Then we are ready to count forms, study movements, or go more deeply into their reason for being. You could not long question the motives of the enthusiastic student, and you would probably soon find yourself as deeply into the problem. "You have but to look at life and you will find it interesting, in whatever form, or from whatever standpoint you view it."

For the second reason I gave a hint as to the economic interest. We may be charged with magnifying this side of the question, since it is from the economic point that we solicit aid in carrying on the work. But the United States Fish Commission would not have been organized in the interests of pure science. It is supposed to deal with problems that affect the food and labor of millions. There were two reasons given for its creation. (1) "An investigation into the cause of the decrease of the seacoast fishes and those of rivers and lakes, with suggestions as to the best methods of restoring the same; and (2) active measures looking toward the propagation and multiplication of the useful food fishes, either by restocking the depleted waters, or by introducing desirable species into new localities."

Allow me to quote from Prof. Reighard on the subject. "In this country the fisherman continues to fish in any locality until it becomes unprofitable. He then moves his base of operations to new waters, until these in turn have been exhausted. He is apt to look upon each new body of water as inexhaustible, and rarely has occasion to ask himself whether it is possible to determine in advance, the number of fish that he may annually take from the water without depleting it.

"On the other hand the fish culturist is likely to plant the fry in waters that are quite unsuited to them; or to plant them in water far to the excess of what the water can support. The fisherman proceeds as a farmer might who imagined that he could continually reap without either sowing or fertilizing; while the fish culturist proceeds often as if convinced that seeds might grow on barren soil, or that two seeds might be made to grow in place of one."

Now, since the whole structure of animal life rests ultimately upon vegetable life, large or small, and since most fish feed upon food produced in the water, we must readily see the interdependence between the larger and the smaller animals and plants. The food of our game fishes, as you know is live animals. The food of these animals is no doubt smaller

living creatures; and so you may follow the series down to the smallest animal, one who can find no smaller victim. Among this lower class are the copepoda. Their food is largely vegetable, and they are no doubt an important element in the survival of the game fish during that critical period of youth. Together with aquatic insects they make up the food of the small fry of the game fishes. In the ocean they form the food of the whale. They are a connecting link in animal life. No man can foresee what would result, and few would believe if told,—if these insignificant animals should cease to be.

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